CHARACTERIZATION OF BACKGROUND BIOLOGICAL AEROSOL

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13. ABSTRACT (Maximum 200 words)

12 hourly biological aerosol samples were collected, using a wet cyclone Aerojet impinger, at the background Mace Head research station, near Carna, Co. Galway, on the west coast of Ireland. Both conventional microscopic analysis as well as an automated digital imaging system (courtesy of DERA, Porton Down) was used to size the aerosol particles. Good agreement was found using the two systems. Size distribution spectra of the biological fraction and the total aerosol population were determined. Background marine aerosol was found to possess lower levels than that of polluted continental air. Quantitative flourescence cross-sections (cm^2/particle) were calculated as a function of excitation wavelength for both background marine and continental air.

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BACKGROUND BIOAEROSOL CHARACTERIZATION

1. Introduction

The release of different bioaerosols is affected by various factors. Intrinsic mechanisms in some organisms forcibly discharge particles usually in response to an environmental factor. Other organisms require a mechanical disturbance for particle release. Seasonal climate changes affect the growth cycles of plants and subsequently the maturation and release cycles of pollen and spores. Diurnal effects are mainly influenced by local weather conditions and meteorological parameters such as temperature, relative humidity, wind direction and wind speed, which can influence the release and aerosolisation of small particles, pollen and spores.

It has been shown (Van den Assem, 1972) that diurnal concentrations of certain airborne pollen groups correlated positively with temperature and negatively with relative humidity. Days with > 50% cloud cover generally resulted in lower pollen concentrations. Rainfall will scrub pollen from the air while inhibiting pollen release from anthers.

Fungi may be grouped as "dry weather fungi" (those releasing spores during dry weather) or "wet weather spores". High relative humidity positively influences the release of a number of fungal spores, eg. the ascomycetes. Ascospore concentrations often peak as a light rain shower begins. Rain stimulates intrinsic mechanisms and also mechanically stimulates by a mechanism known as rain splash. Certain "dry weather spores" were found to increase in concentration before and after rain showers, (Hjelmroos, 1993). Increased concentrations of some fungal spores (Pedgley,1982; Leach, 1975) have been associated with low relative humidity. Light-dark cycles also seem to affect spore release. However, temperature, humidity and light levels do not appear to affect spore release in all fungi. In general, fungal spores are somewhat resistant to environmental stresses encountered during transport through the air.

No active (intrinsic) release mechanisms are known for bacteria. Most likely, bacteria are released by mechanical agitation, including wind, disturbance by animals, human

activities such as manipulation of compost and agricultural work. Human pathogens are released by coughing and sneezing. The background aerosol may be attributed to bacteria released from leaf surfaces by the wind and areas of exposed soil. Bacteria seem to be more susceptible to environmental stress than are fungal spores and pollen, although bacterial endospores eg. Bacillus species are quite resistant (Knudsen and Spurr, 1987).

2. Fluorescence Protocol

The protocol for bioaerosol sampling and subsequent chemical treatment of collected samples has been documented in the 1st Interim Report. Excitation/emission (EEM) spectra have been generated producing two dimensional plots of fluorescence intensity as a function of emission and excitation wavelength. Corrected emission spectra for samples and water have been integrated in order to calculate fluorescence cross sections (cm^2/sr/particle) The fluorescence protocol used and calculation of the fluorescence cross section have been described in the 2nd Interim Report.

3. Microscopic Analysis of Bioaerosol Particles

The primary disadvantage of using microscopy for routine monitoring of bioaerosols is that it is time and skill intensive. Computerised methods that automate the actual counting procedure allows fast and accurate results to be obtained. Microscopic analysis is transcending into the discipline of analytical imaging, in effect any image obtained microscopically can be digitised. The quality of the digitised image however is still dependent on the clarity of the primary microscopic image. Therefore the most advanced microscopic applications are only as good as basic light microscopy will allow.

The protocol for microscopic analysis of filters has been documented in the 1st Interim report. In addition to light microscopic analysis, filters have been examined using a Kontran Elektronic (KS 400) digital imaging system. This system utilises a Nikon Microphot-FXA video camera attached to a Nikon microscope. The digital imaging system has the capability of sizing particles down to an equivalent diameter of 0.4 μm

at x 400 magnification. Analysis was therefore extended to include particles of equivalent diameter < 1 μm down to 0.4 μm in size (0.4 μm < d < 1 μm).

4. Results and Discussion

Eight 12 hourly bioaerosol samples were collected at Mace Head over the period of July to December 1997. A combination of meteorological and condensation nuclei (CN) data were used to determine air mass sources. Data include bioaerosol samples from both marine (wind sector 180-300°) and continental air sources (45-135°).

The samples were evaluated into size classes (0.4 μm < d > 51.2 μm) and the size distributions of the total aerosol particles and biological particles were obtained. These were plotted as number concentration dN/dlogD per ml versus equivalent diameter (μm) and are presented in Figures 1, 3, 5, 7, 9, 11, 13, 15. Additionally, the number concentration dN/dlogD per ml was calculated for the total number of black (non-biological) and transparent (non-biological) particles in each diameter interval and are presented in Figures 2, 4, 6, 8, 10, 12, 14, 16.

In general, lower number concentration levels, by factors between about 2-3 were found for marine air as compared to continental air. However, for larger sized particles (diameter ≥ 10 μm), marine air biological particles were generally dominant. The highest concentration of particles occurs during a continental episode on the 10/23/97, on comparing the total aerosol size distributions for the eight sampling periods. A peak concentration occurs in the size intervals of diameter < 3.2 μm for all samples. The highest concentration of particles in the size range of 3.2 μm < d < 6.4 μm occurs during the continental periods of 09/19/97, 10/23/97 and 12/02/97.

Similarly, on comparing the size distribution of black particles for all eight samples, the highest concentrations also occur during the continental sampling period 10/23/97. The highest concentration of particles occurs in the size ranges < 3.2 μm for all samples. The highest concentration of particles in the size range of 3.2 μm < d < 6.4 μm also occurs during the continental periods of 09/19/97, 10/23/97 and 12/02/97.

The highest concentration of biological particles at the size intervals of diameter 0.4-0.8 μm, 0.8-1.6 μm, and 3.2-6.4 μm occurs during the continental period 10/23/93. The peak biological particle concentration at the size interval of diameter 1.6-3.2 μm occurs during the continental period 09/19/97.

The continental period 10/23/97 has the highest concentration of transparent particles. Most samples have a peak concentration occurring in the size interval of diameter 0.8-1.6 μm with the exception of the marine period 08/15/97 which has a peak transparent particle concentration at the size interval 1.6-3.2 μm.

A comparative study was carried out to compare sample 09/05/97 counted by both light microscopy and the digital imaging system. The results are presented in Figure 17. Agreement between the two systems is good, particularly for the size intervals of diameter 1.6-3.2 μm and 6.4-12.8 μm. A comparative study was also carried out on blank samples and the results are presented in Figure 18. Both blanks counted by light microscopy agree quite well with one another but blank 1 counted by light microscopy is comparatively lower than when counted by the digital imaging system. This is probably due to the fact that the digital system had a lower particle detection cut-off size.

Representative emission spectra for the sampling periods are shown in Figures 19 (a) through to 25 (h). No emission spectra are available for the period 12/02/97 due to instrumentation failure. Fluorescence cross sections (cm^2/sr/particle) have been calculated for each spectrum and are presented in Table 1.

5. References

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Pedgley, D.E. (1982). Windborne pests and diseases, Meteorology of Airborne Organisms. Ellis Horwood Ltd., Chichester, England.

Van den Assem, A. (1972). Airborne pollen in relation to pollinosis. In: Nilsson, S., Ed., *Scandinavian Aerobiology*, Bulletins from the Ecological Research Committee No. 18, Swedish Natural Science Research Council.

6. Acknowledgments

We wish to acknowledge DERA, Porton Down and the CB team including Nigel Pomeroy and James Burke for facilitating the use of an automated particle sizing imaging system.

Table 1

ExcitationWavelength	**Fluorescence Cross Section σ_F (cm^2/organism/sr)**						
λ (nm)	07/31/97 Marine	08/15/97 Marine	09/05/97 Marine	09/19/97 Continental	10/02/97 Marine	10/09/97 Marine	10/23/97 Continental
254	1.4E-6	4.5E-7	8.5E-7	3.3E-7	4.4E-7	1.3E-6	7.2E-8
262	6.5E-7	1.5E-7	3.1E-7	1.5E-7	3.4E-7	6.7E-6	3.1E-8
270	2.6E-7	3.0E-7	1.3E-7	6.2E-8	1.6E-7	2.5E-7	1.2E-8
278	2.1E-7	4.6E-8	1.0E-7	5.1E-8	1.4E-7	1.9E-7	1.2E-8
286	1.9E-7	4.2E-8	1.1E-7	5.2E-8	1.1E-7	2.1E-7	1.4E-8
294	1.5E-7	2.9E-8	8.6E-8	4.0E-8	9.4E-8	1.7E-7	1.3E-8
302	1.2E-7	2.6E-8	6.6E-8	3.4E-8	1.0E-7	1.45E-7	9.7E-9
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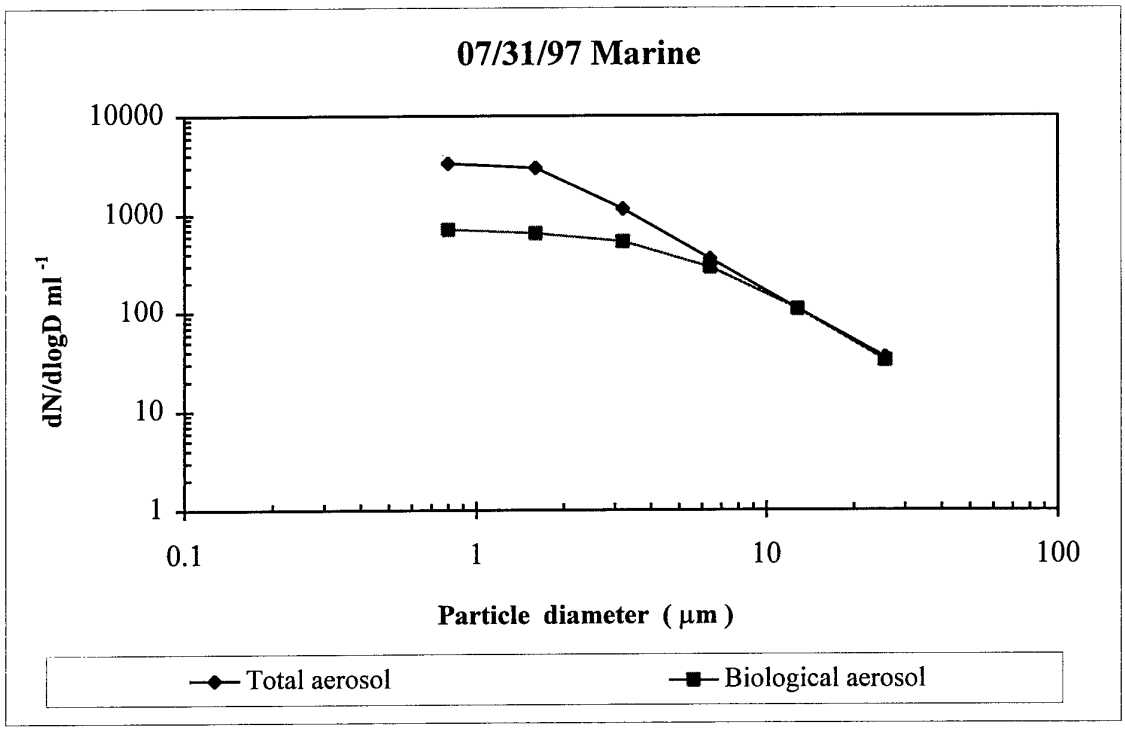

Figure 1. Total and biological aerosol size distribution. dN/dlogD per ml vs. diameter (μm).

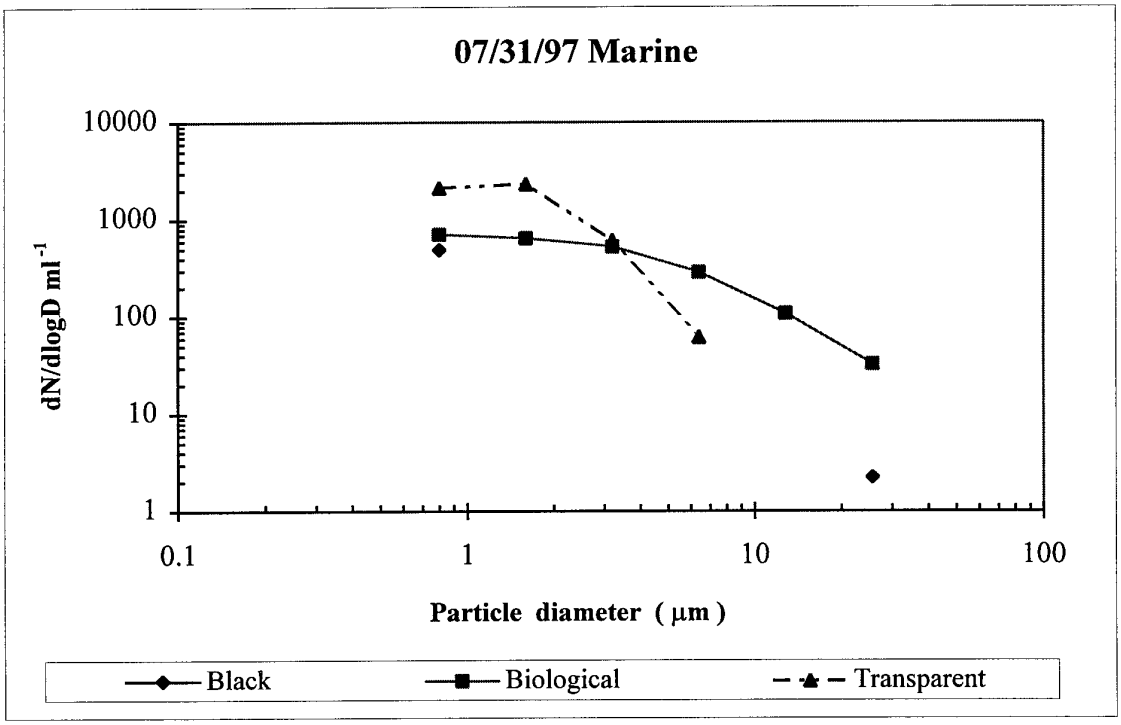

Figure 2. Black, biological and transparent particle size distribution.
dN/dlogD per ml vs. diameter (μm).

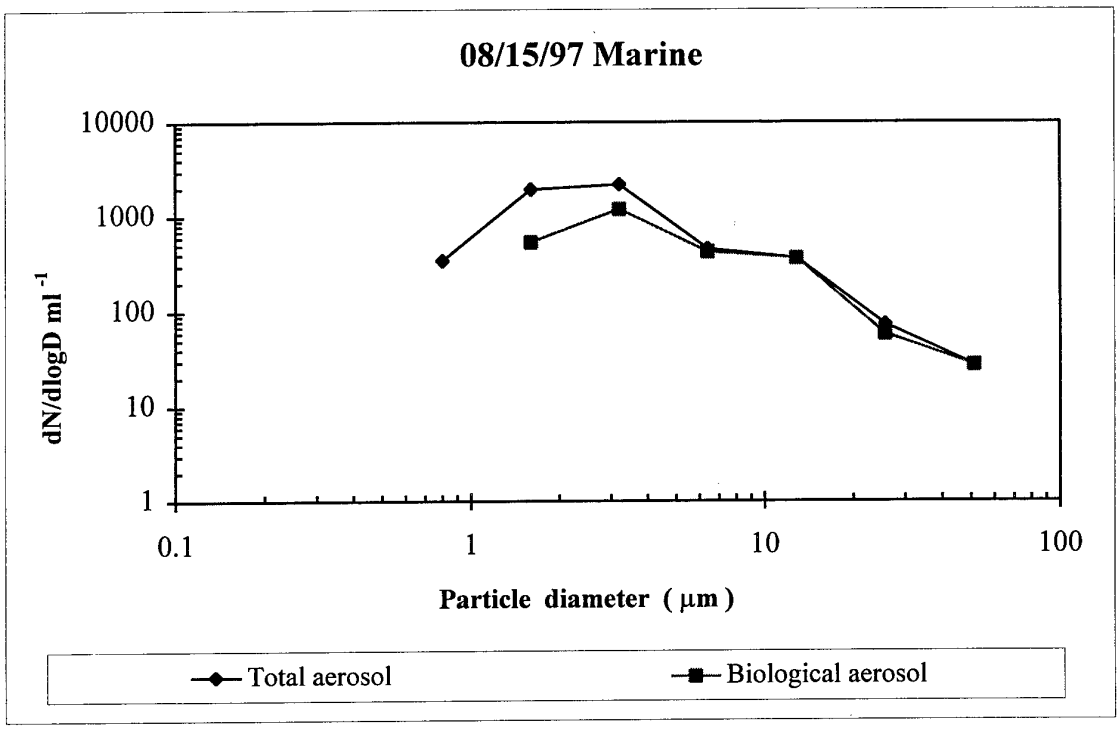

Figure 3. Total and biological aerosol size distribution. dN/dlogD per ml vs. diameter (μm).

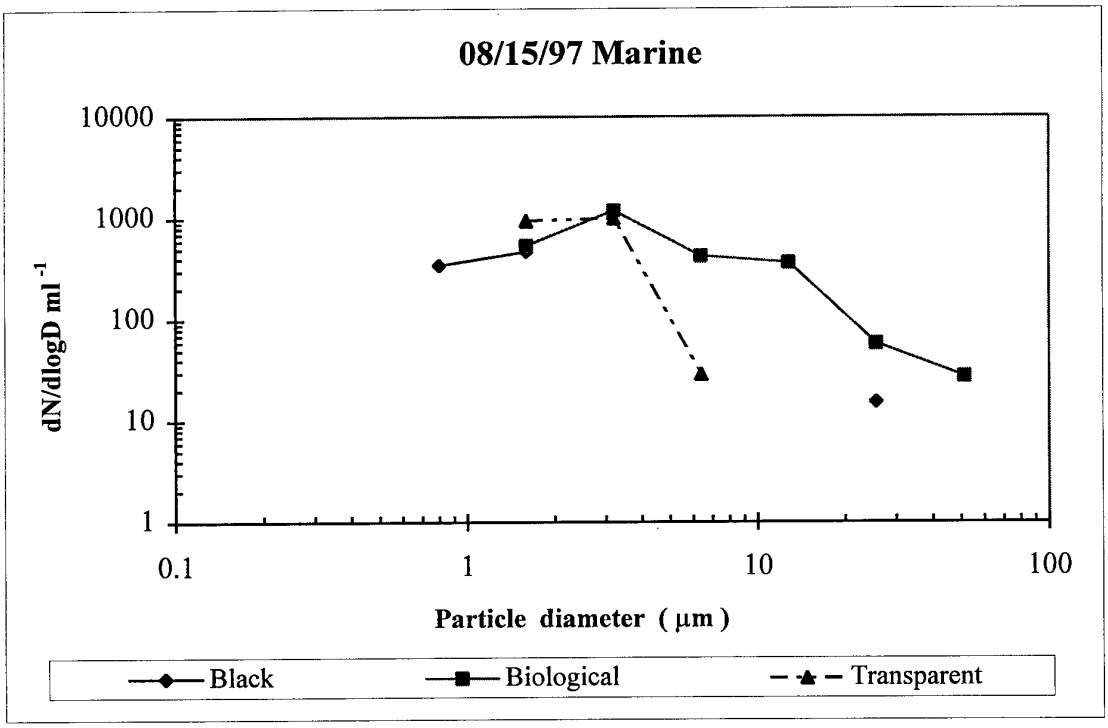

Figure 4. Black, biological and transparent particle size distribution.
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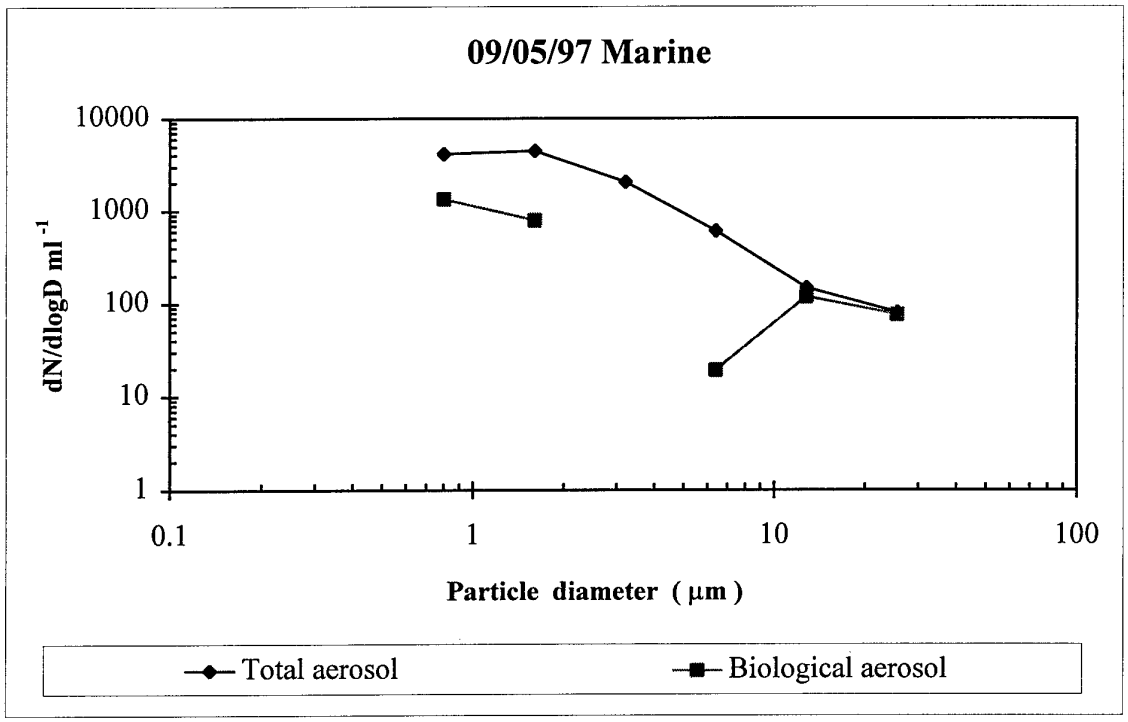

Figure 5. Total and biological aerosol size distribution. dN/dlogD per ml vs. diameter (µm).

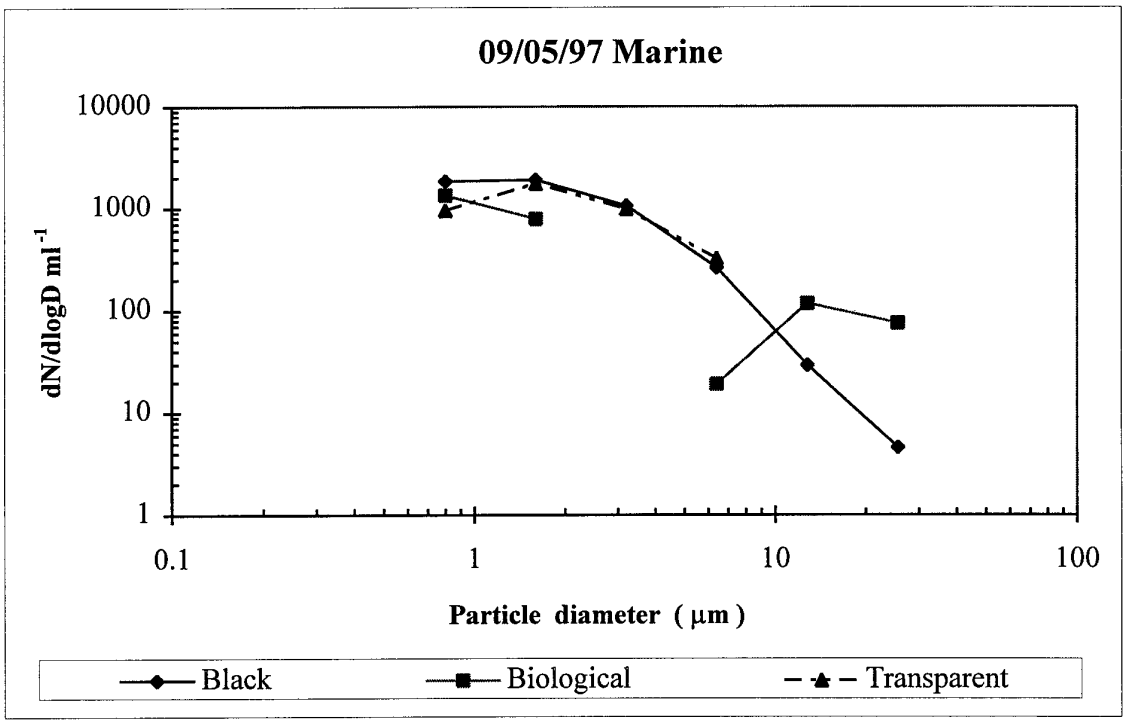

Figure 6. Black, biological and transparent particle size distribution.
dN/dlogD per ml vs. diameter (µm).

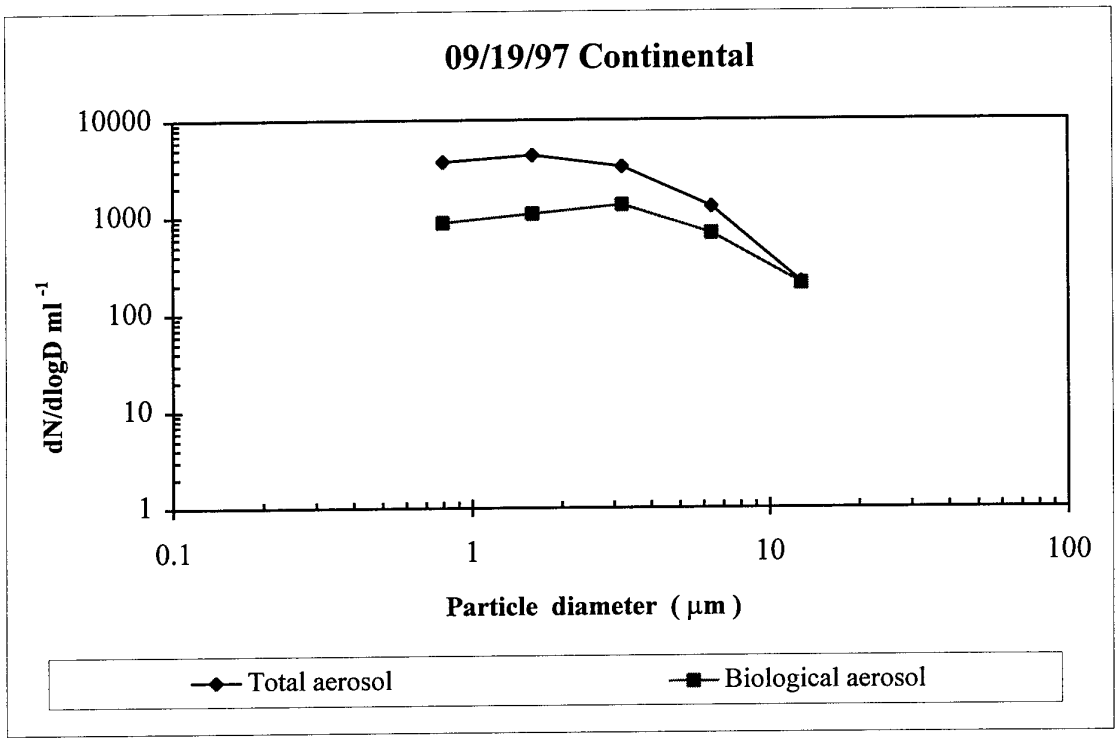

Figure 7. Total and biological aerosol size distribution. dN/dlogD per ml vs. diameter (µm).

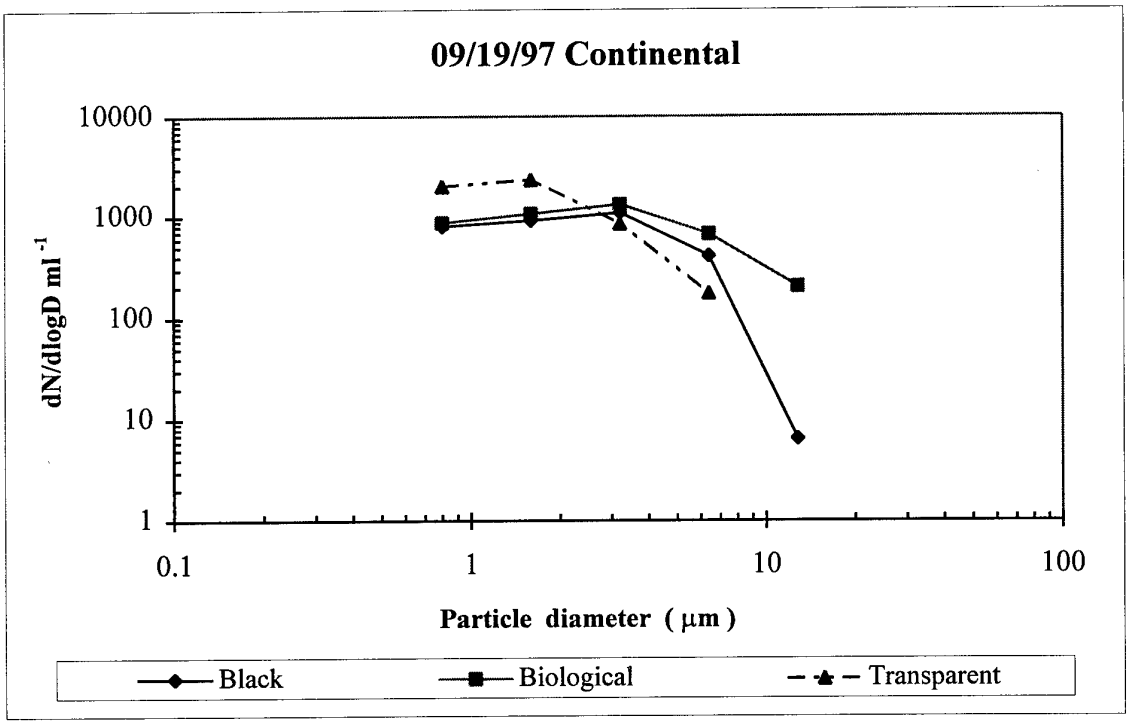

Figure 8. Black, biological and transparent particle size distribution.
dN/dlogD per ml vs. diameter (µm).

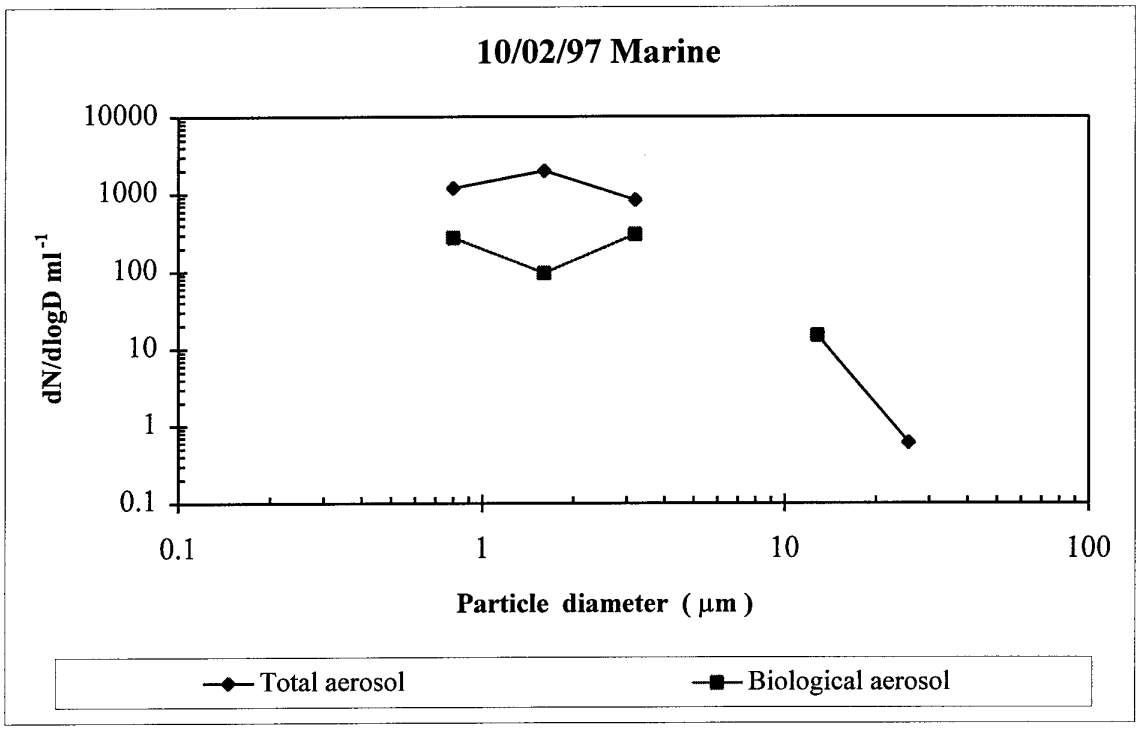

Figure 9. Total and biological aerosol size distribution. dN/dlogD per ml vs. diameter (µm).

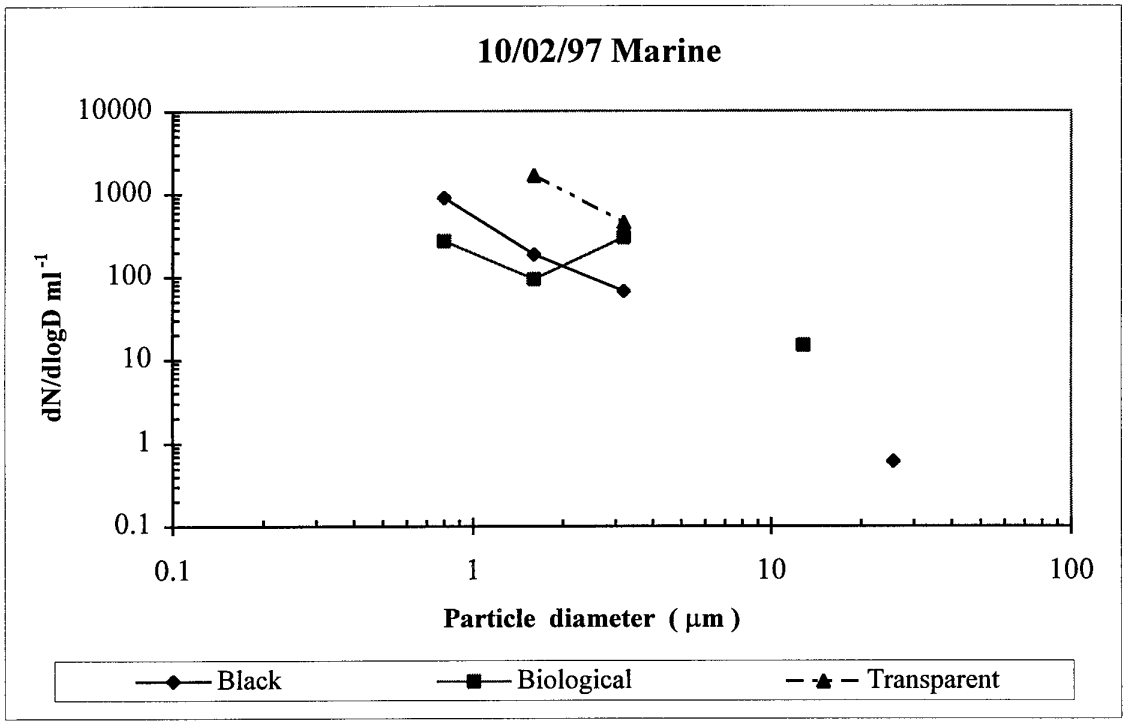

Figure 10. Black, biological and transparent particle size distribution.
dN/dlogD per ml vs. diameter (µm).

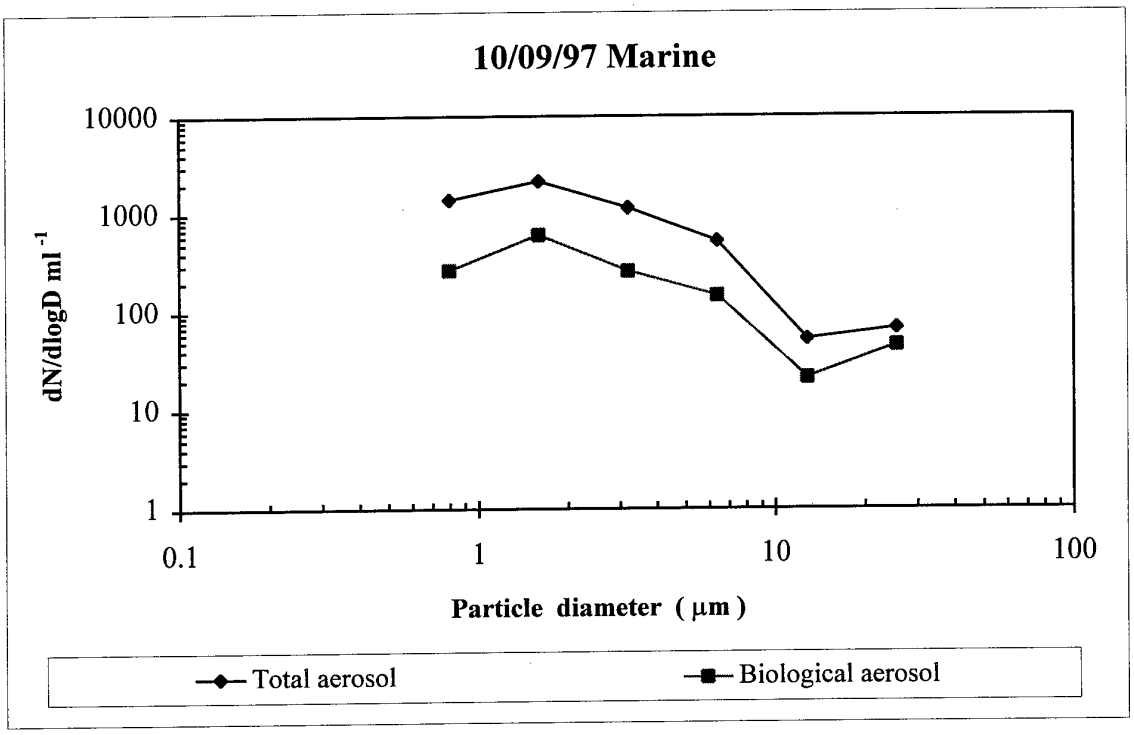

Figure 11. Total and biological aerosol size distribution. dN/dlogD per ml vs. diameter (µm).

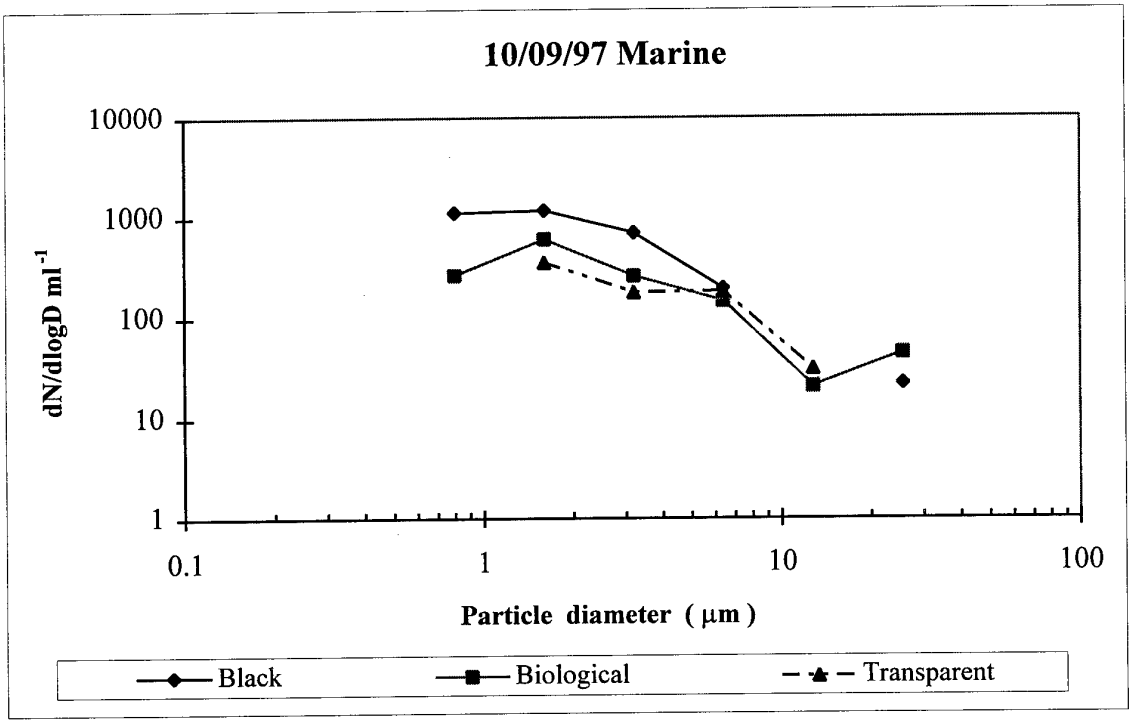

Figure 12. Black, biological and transparent particle size distribution.
dN/dlogD per ml vs. diameter (µm).

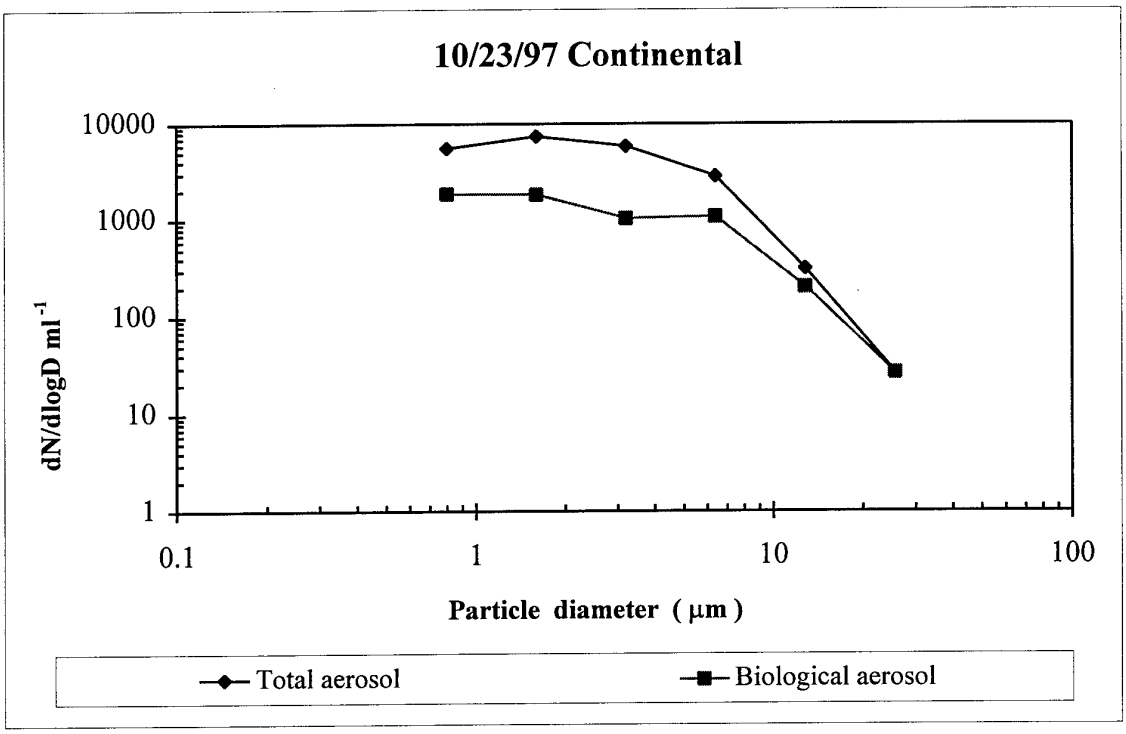

Figure 13. Total and biological aerosol size distribution. dN/dlogD per ml vs. diameter (μm).

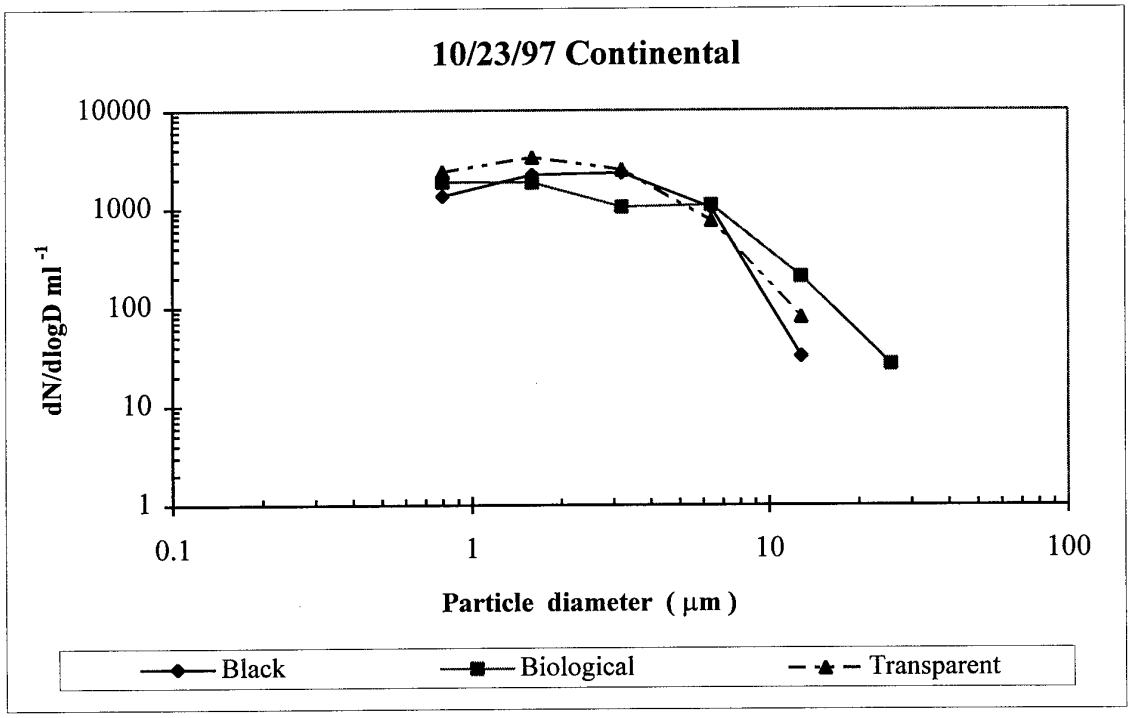

Figure 14. Black, biological and transparent particle size distribution.
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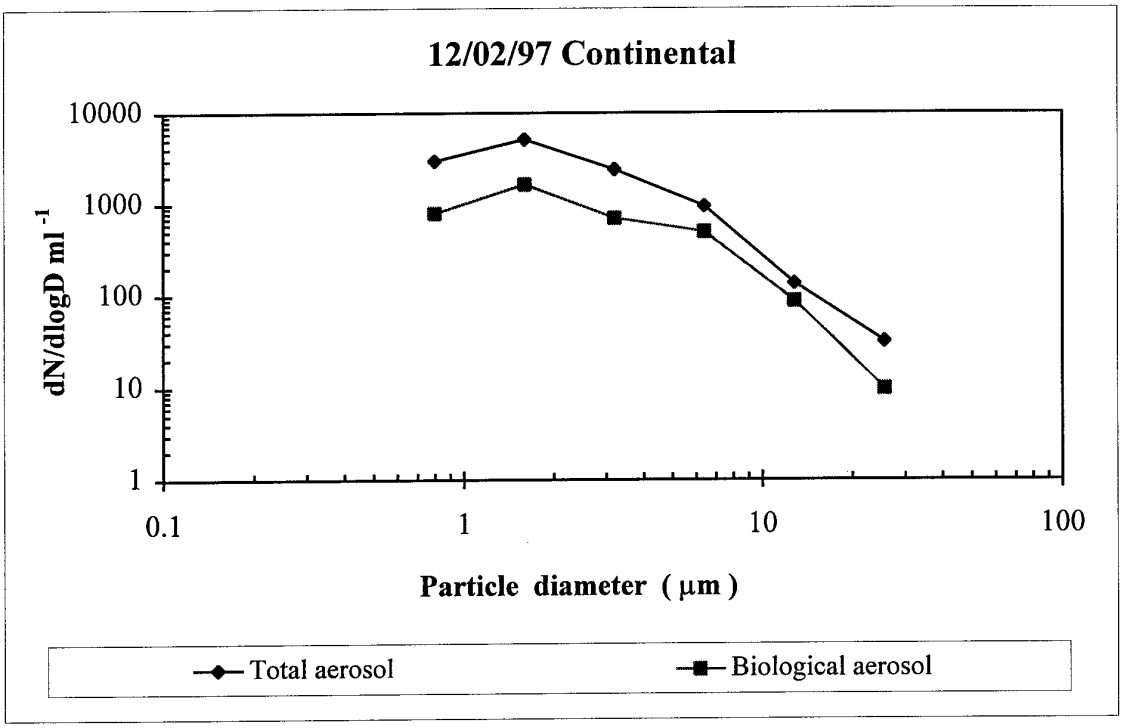

Figure 15. Total and biological aerosol size distribution. dN/dlogD per ml vs. diameter (μm).

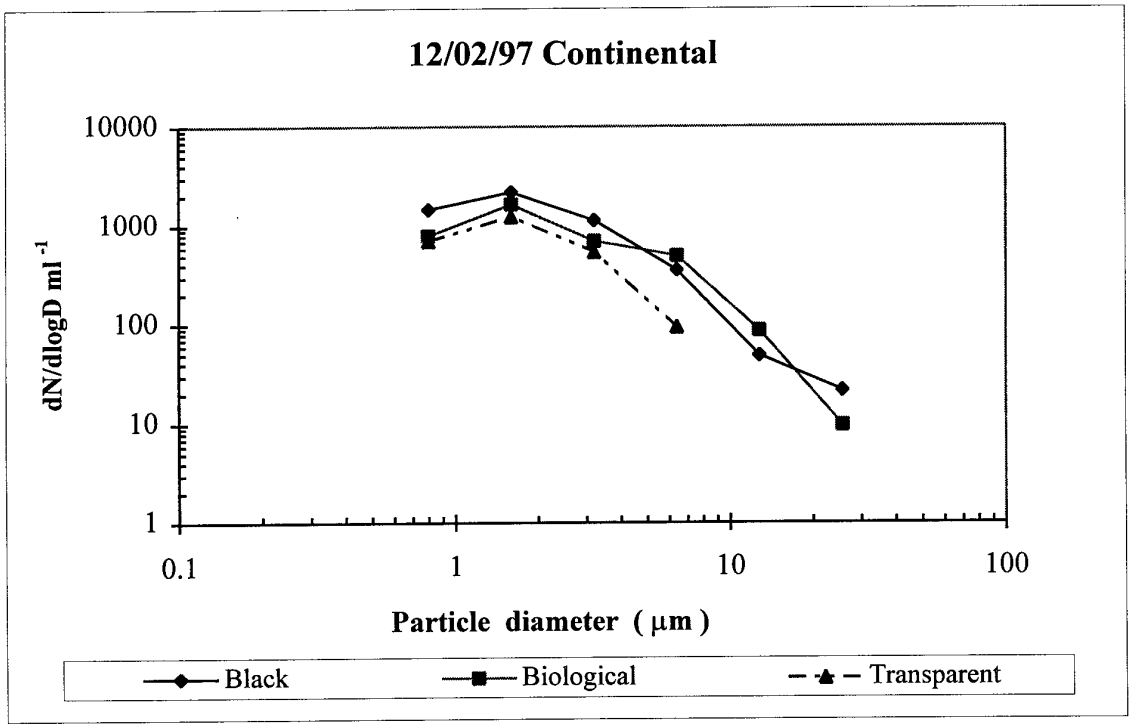

Figure 16. Black, biological and transparent particle size distribution.
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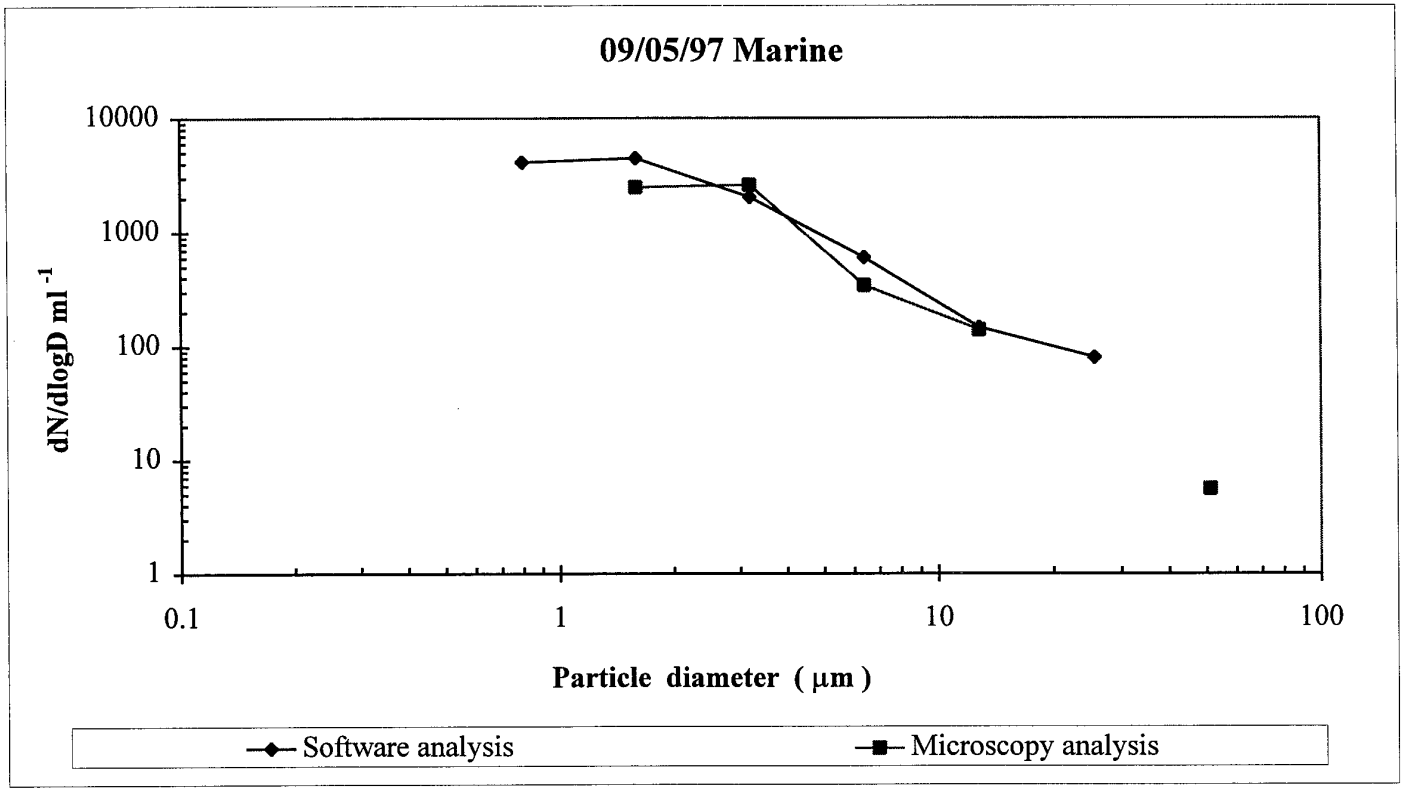

Figure 17. Total aerosol size distribution. dN/dlogD per ml vs. diameter (µm).

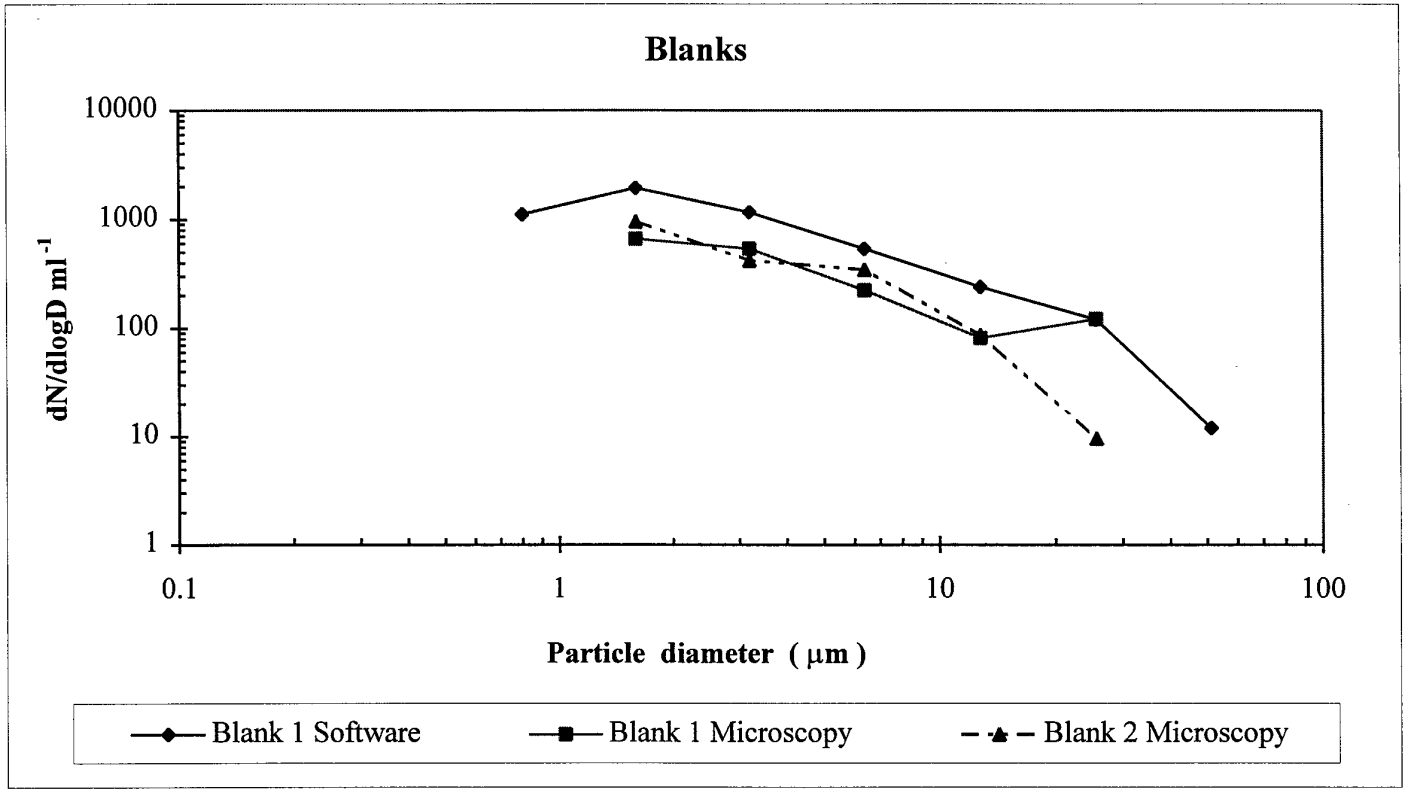

Figure 18. Total aerosol size distribution. dN/dlogD per ml vs. diameter (μm).

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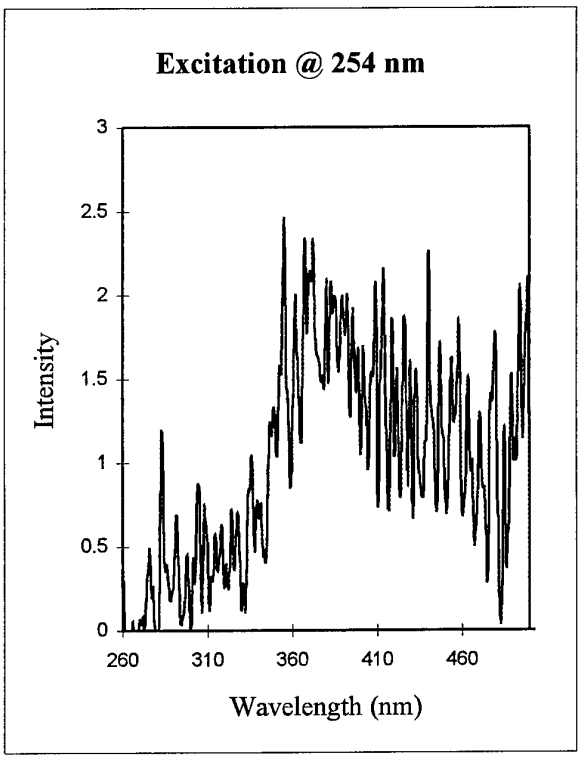

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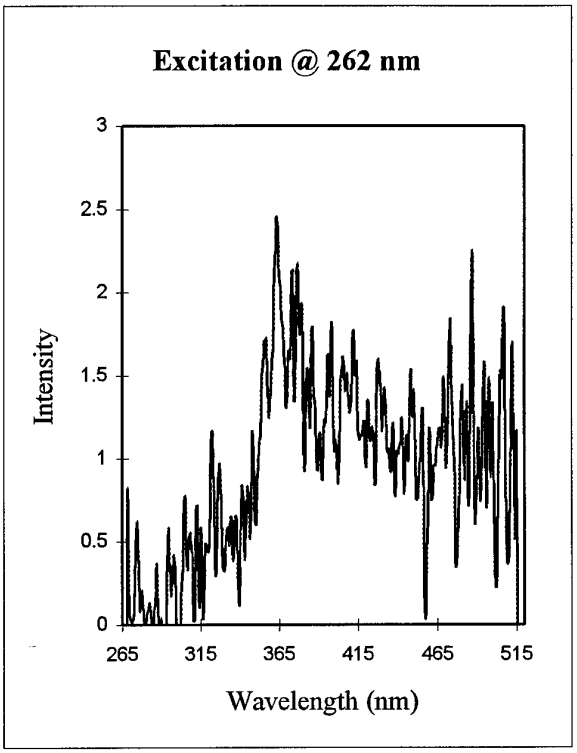

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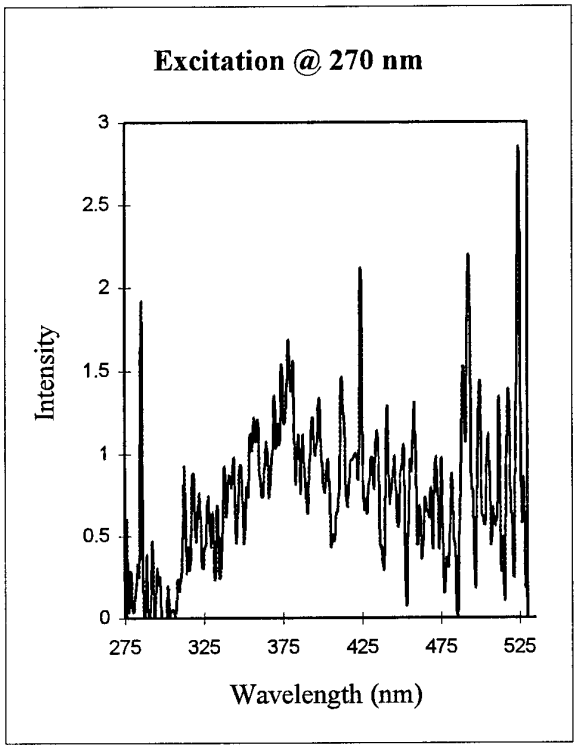

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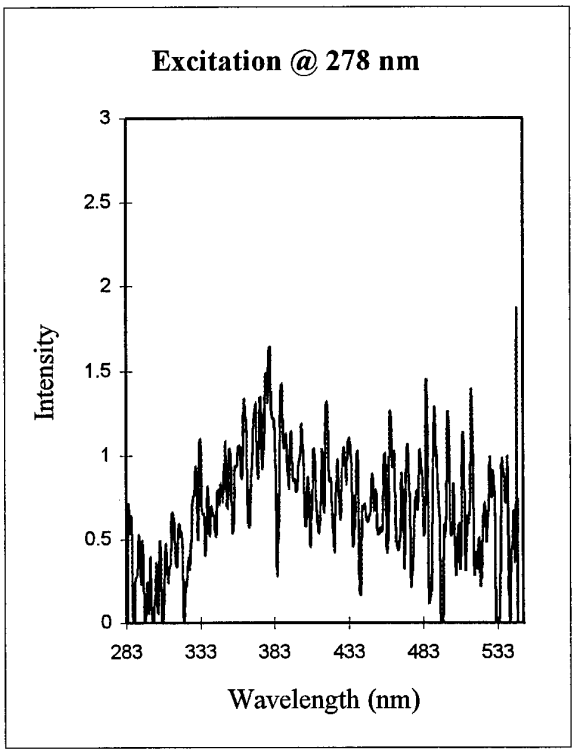

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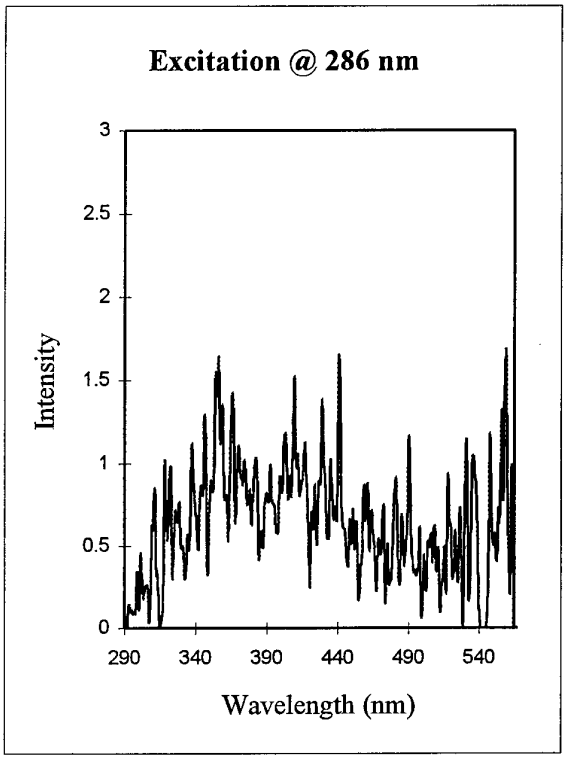

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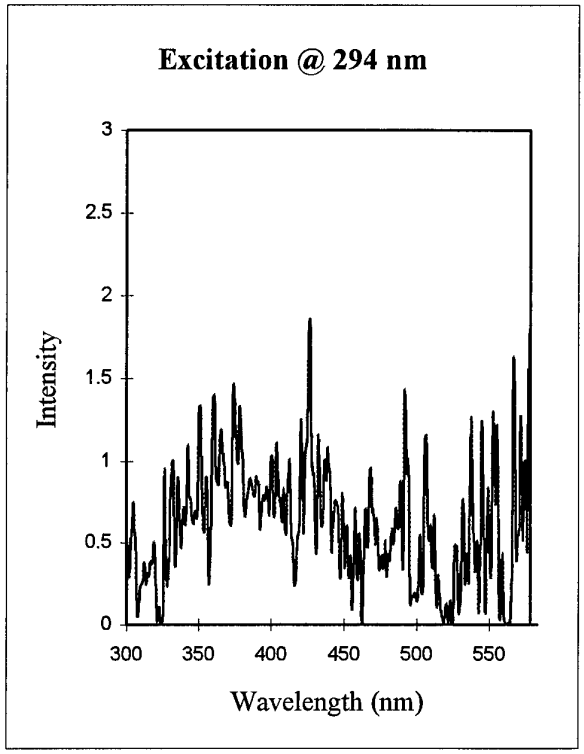

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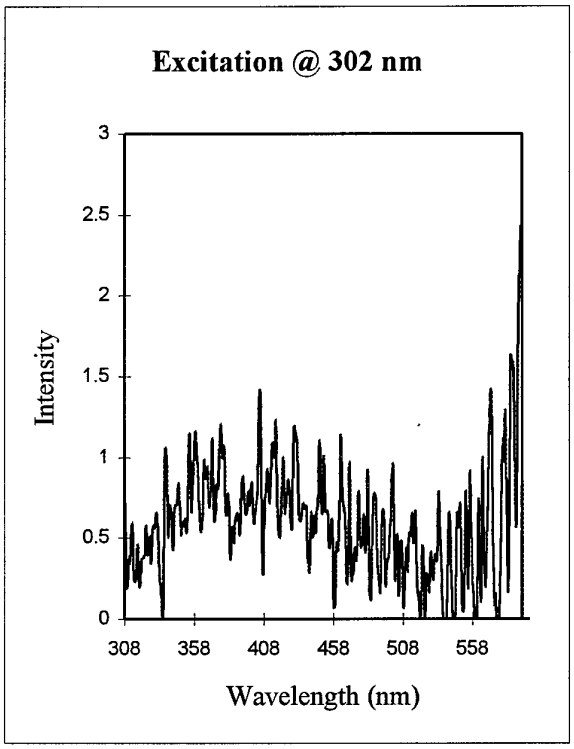

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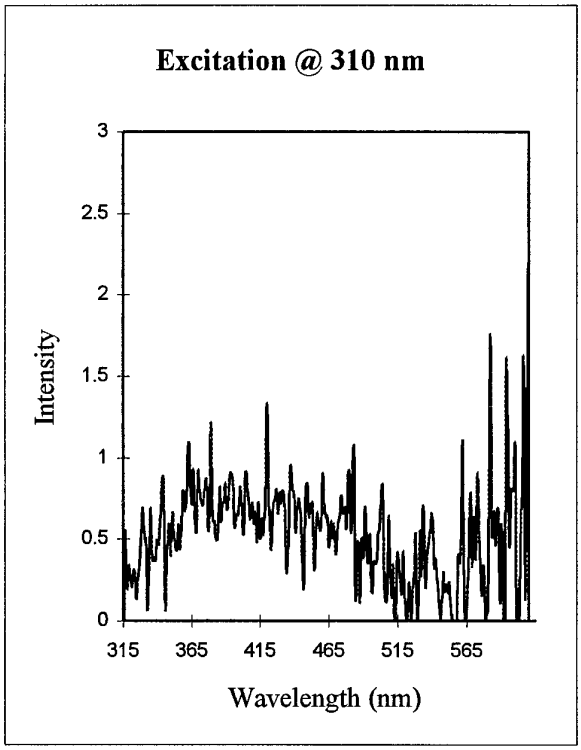
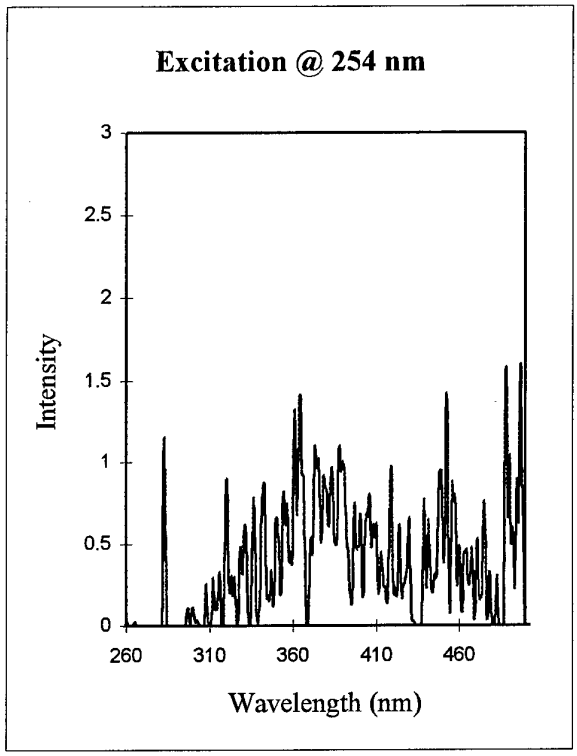


Figure 20 (a) 08/15/97 Marine



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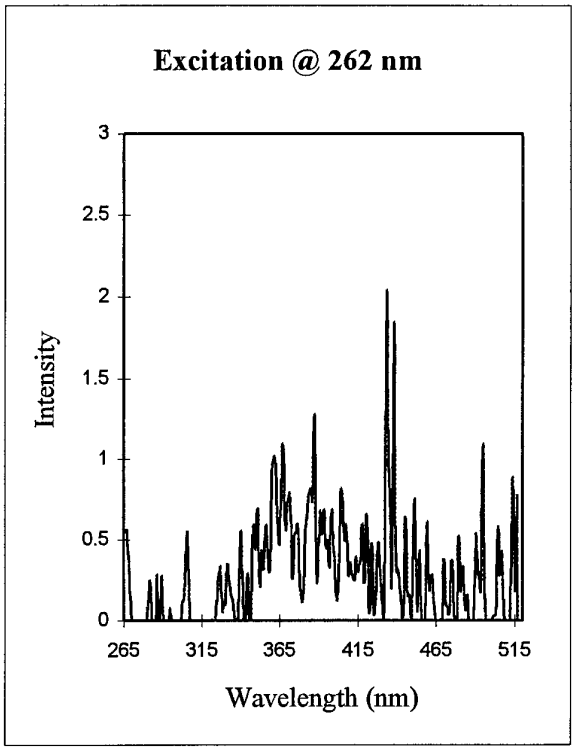

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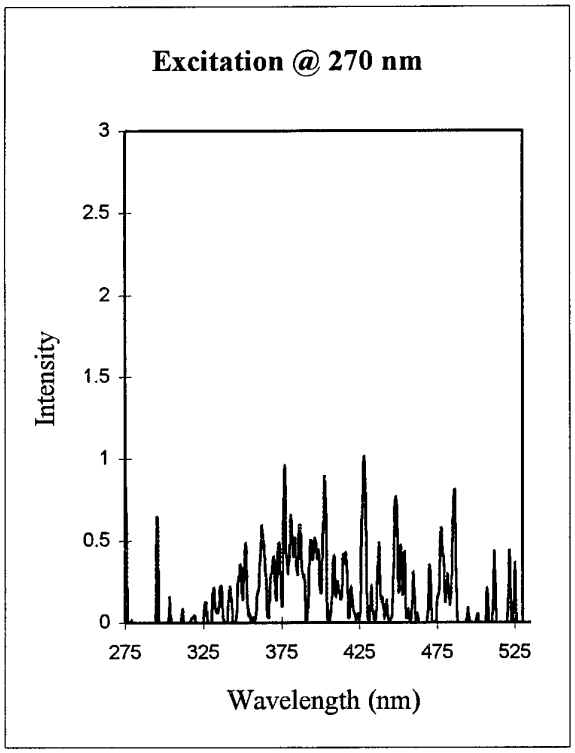

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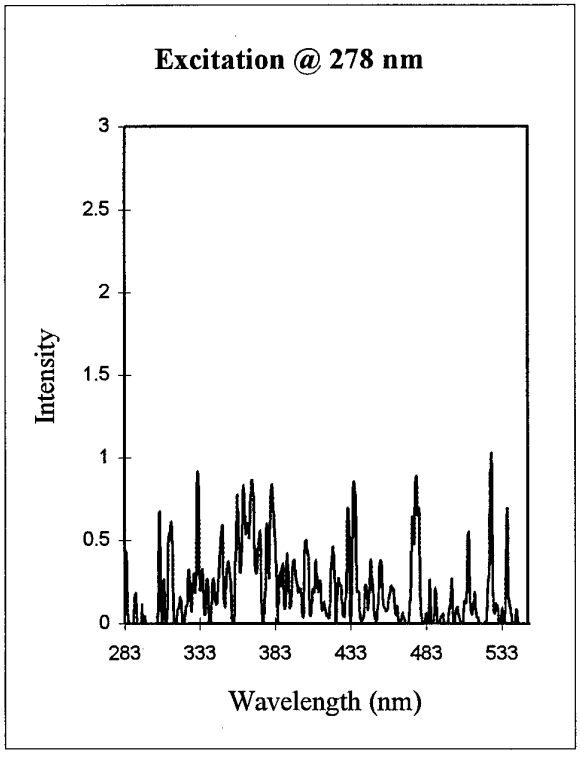

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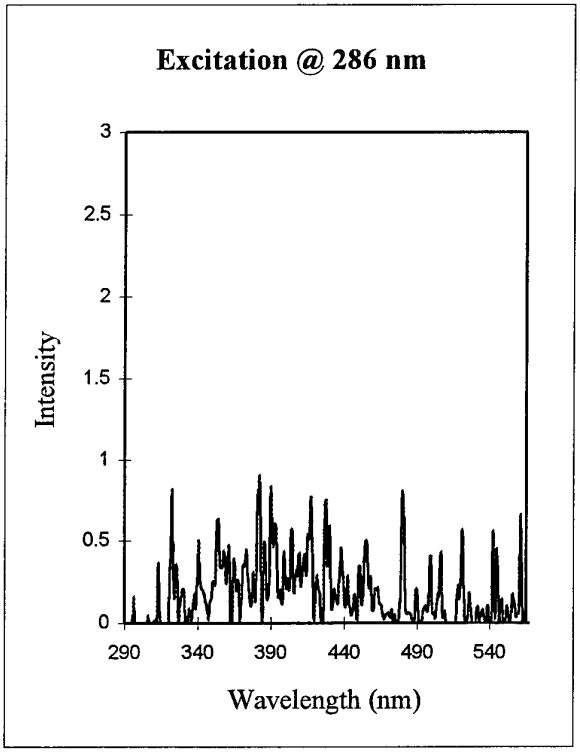

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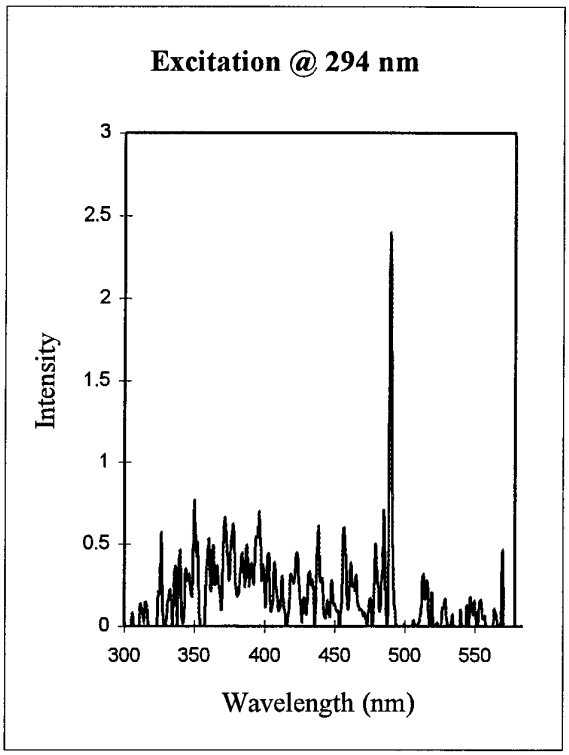

Figure 20 (g) 08/15/97 Marine

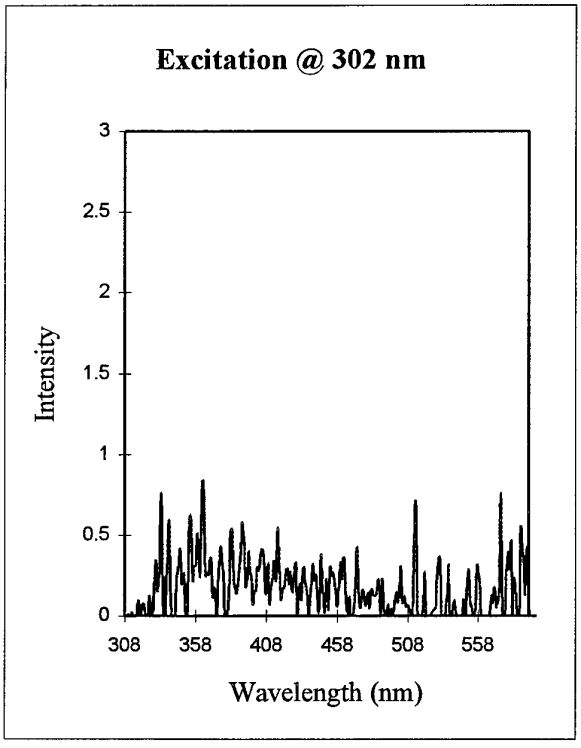

Figure 20 (h) 08/15/97 Marine

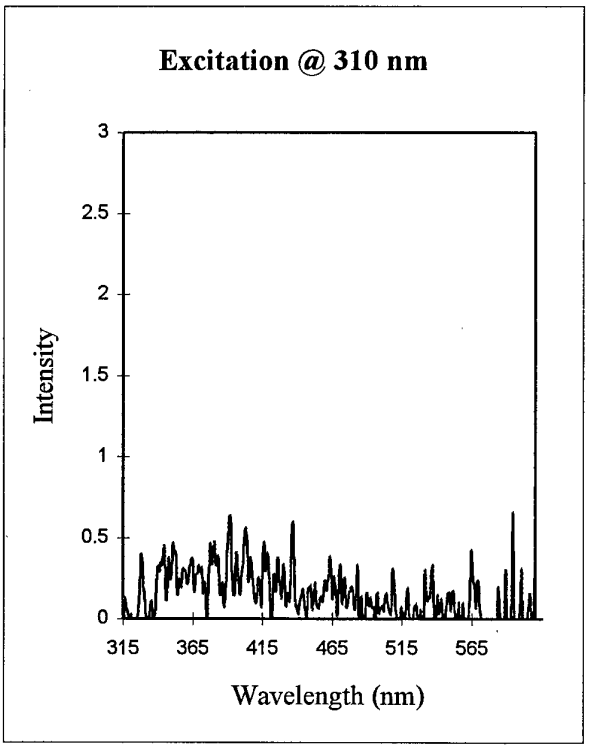

Figure 21 (a) 09/05/97 Marine

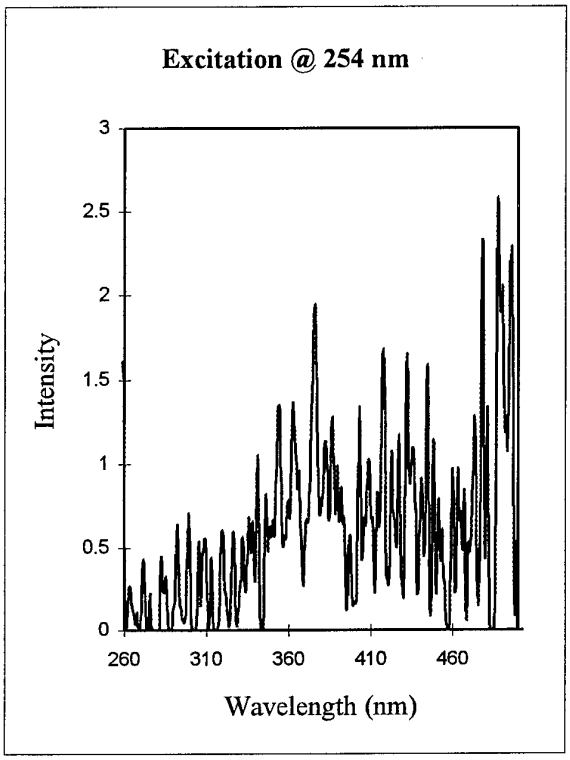

Figure 21 (b) 09/05/97 Marine

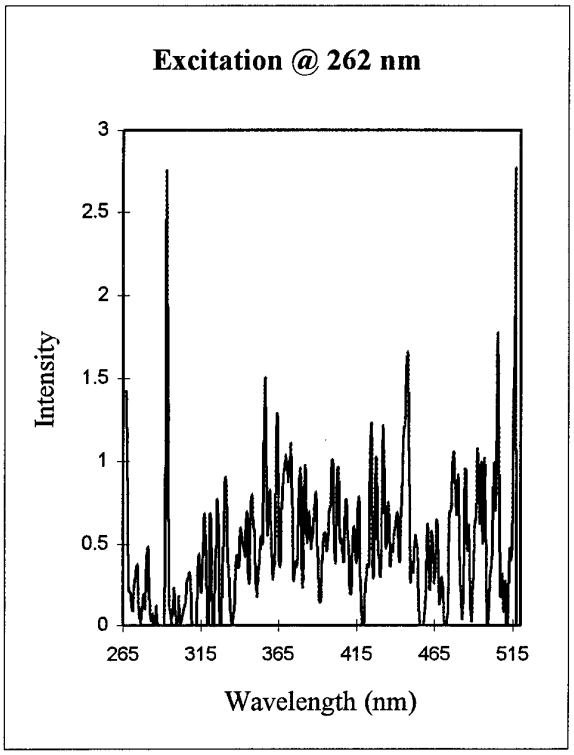

Figure 21 (c) 09/05/97 Marine

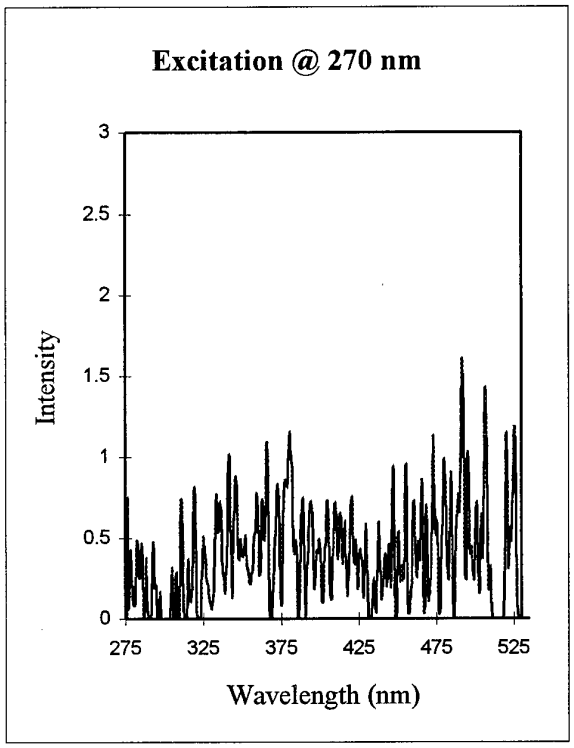

Figure 21 (d) 09/05/97 Marine

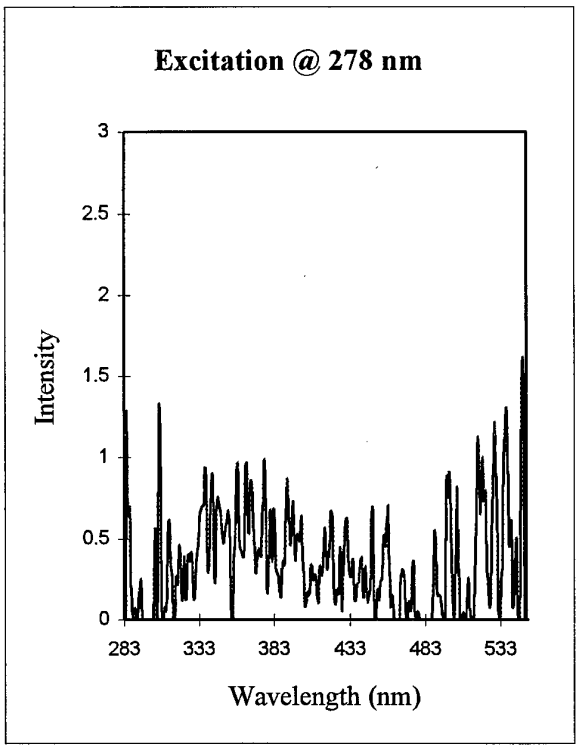

Figure 21 (e) 09/05/97 Marine

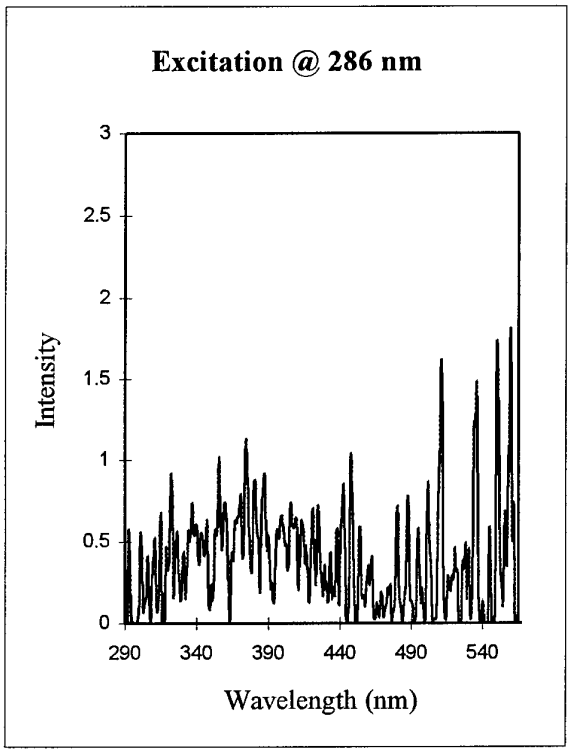

Figure 21 (f) 09/05/97 Marine

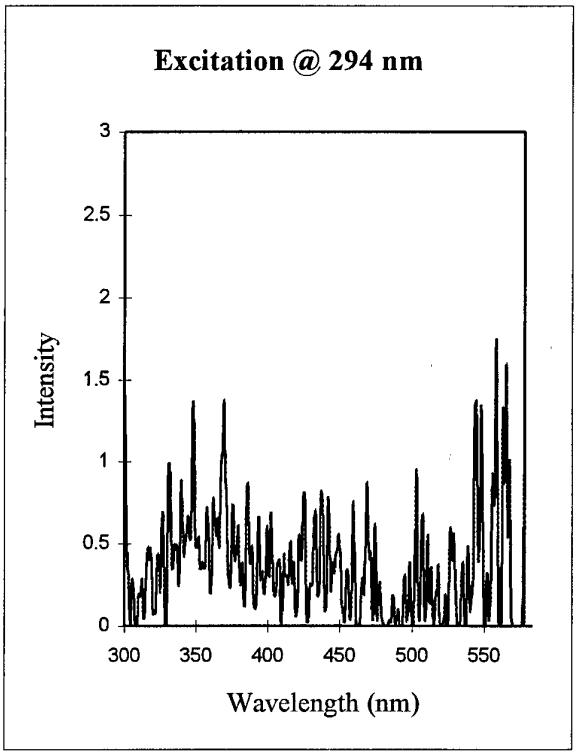

Figure 21 (g) 09/05/97 Marine

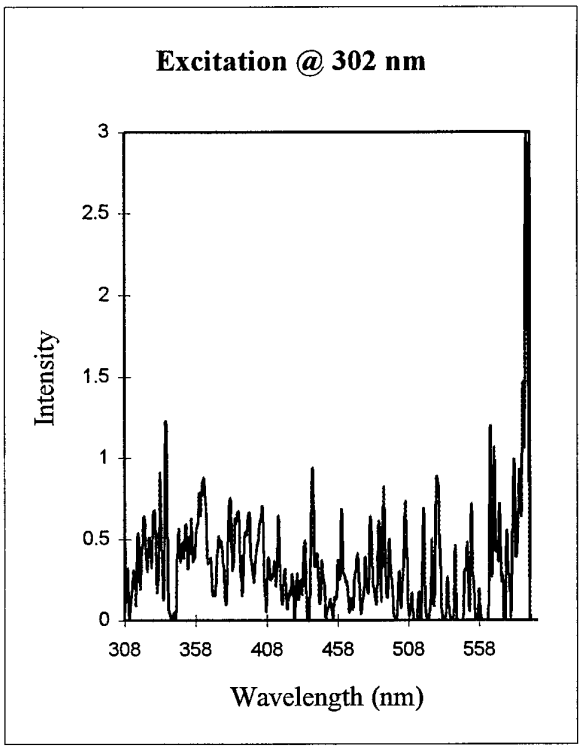

Figure 21 (h) 09/05/97 Marine

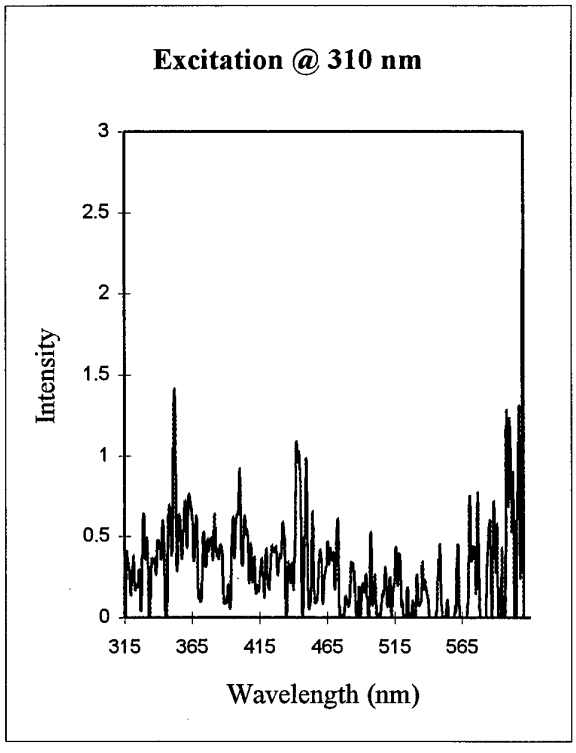

Figure 22 (a) 09/19/97 Continental

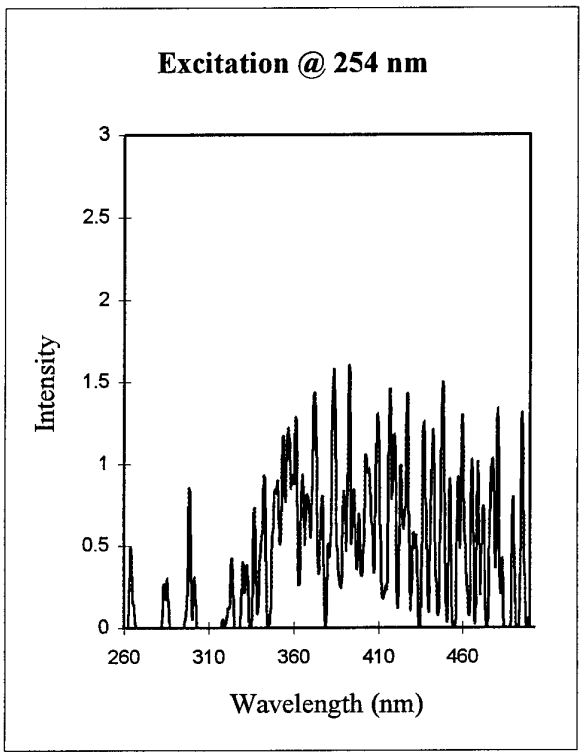

Figure 22 (b) 09/19/97 Continental

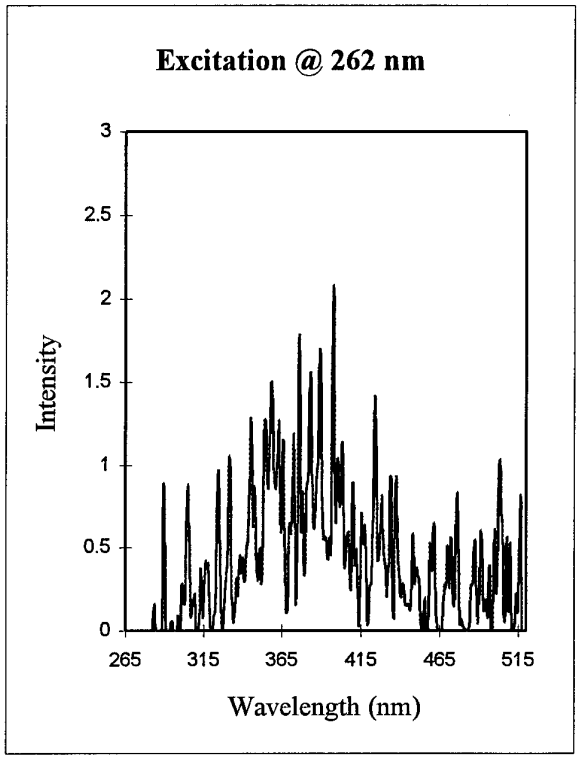

Figure 22 (c) 09/19/97 Continental

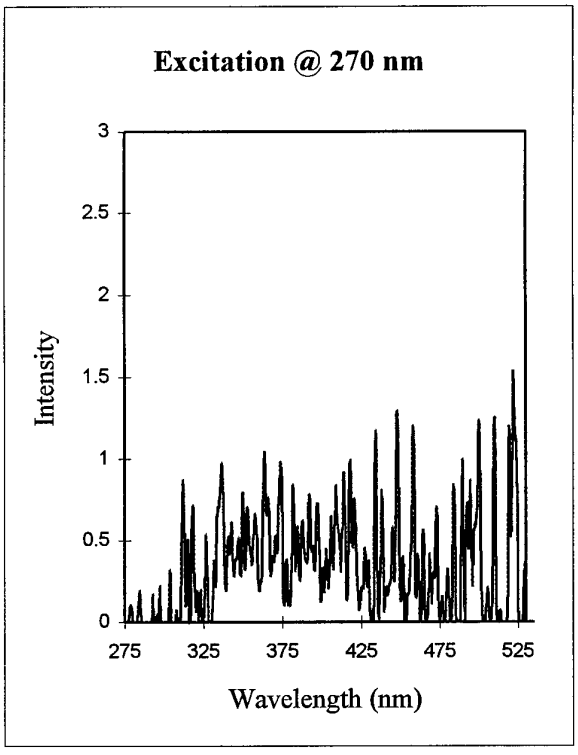

Figure 22 (d) 09/19/97 Continental

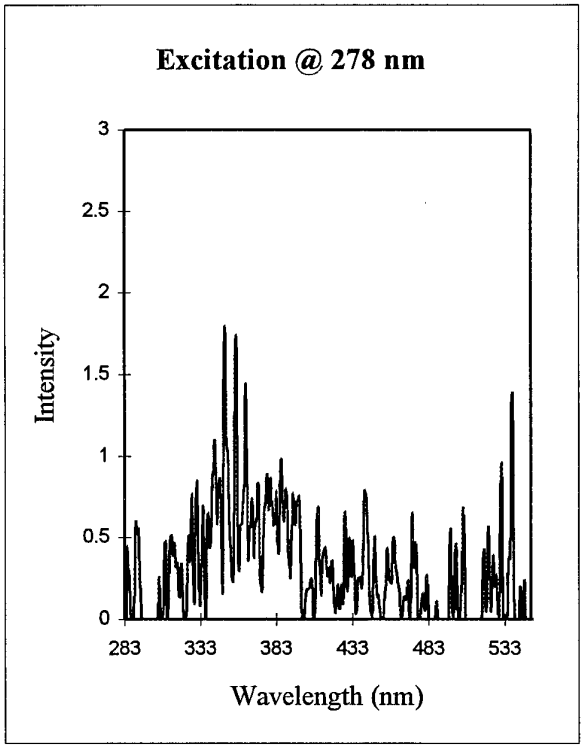

Figure 22 (e) 09/19/97 Continental

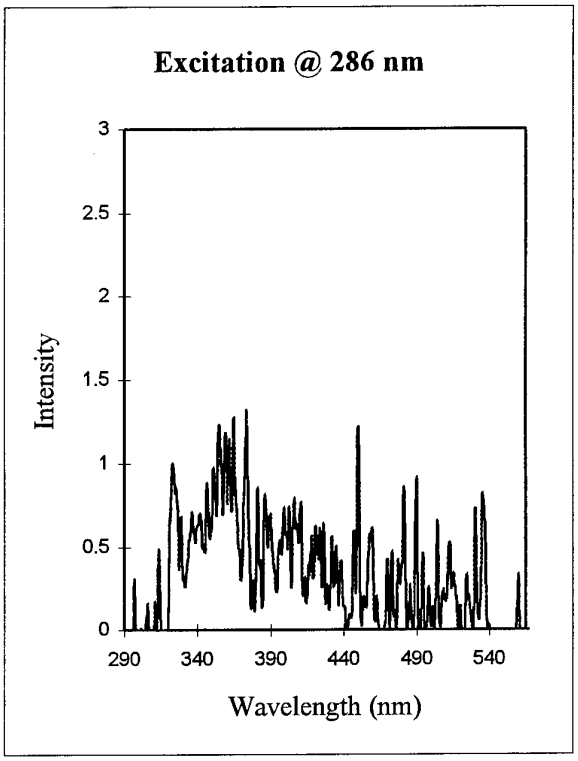

Figure 22 (f) 09/19/97 Continental

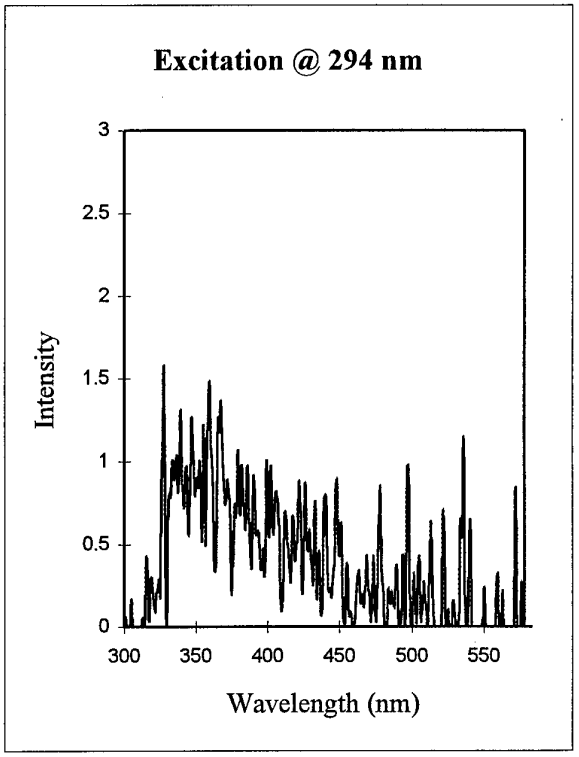

Figure 22 (g) 09/19/97 Continental

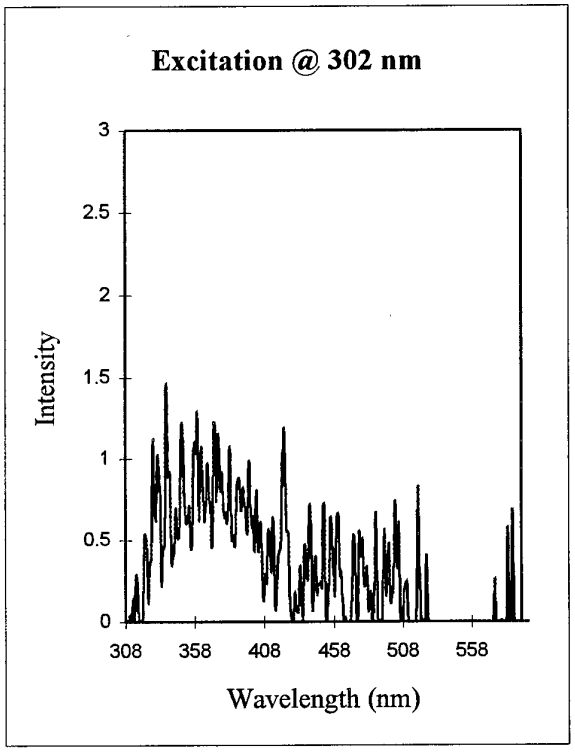

Figure 22 (h) 09/19/97 Continental

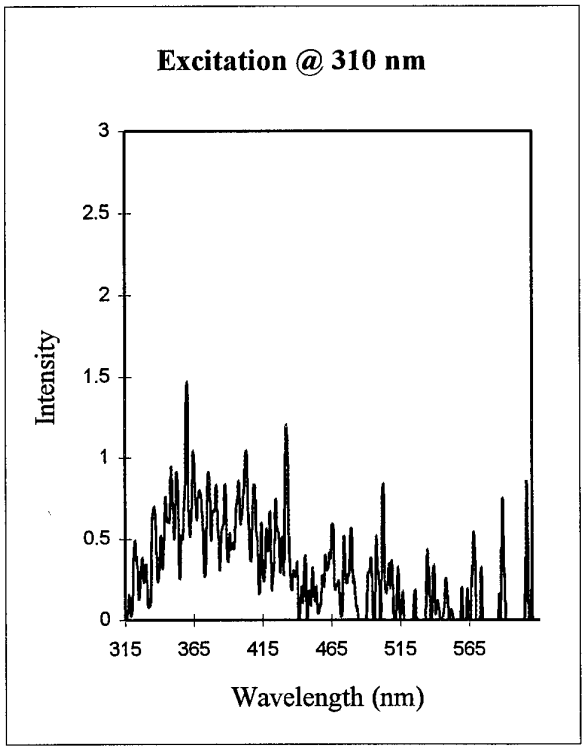

Figure 23 (a) 10/02/97 Marine

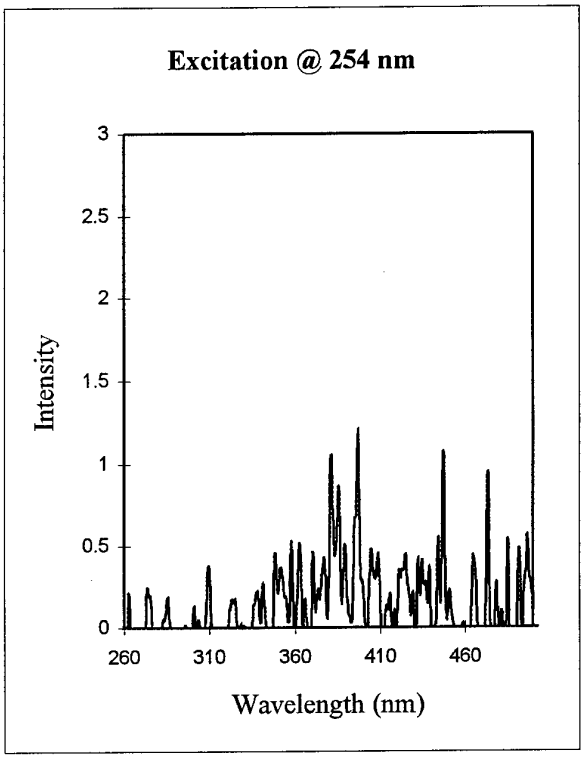

Figure 23 (b) 10/02/97 Marine

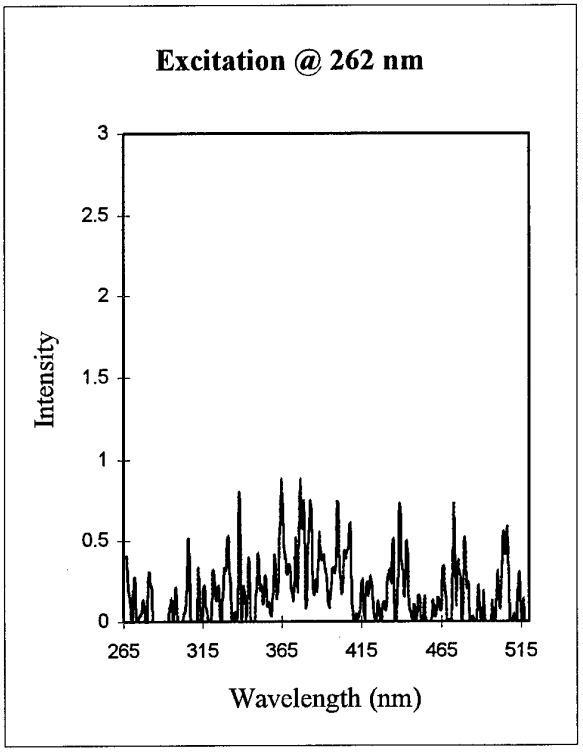

Figure 23 (c) 10/02/97 Marine

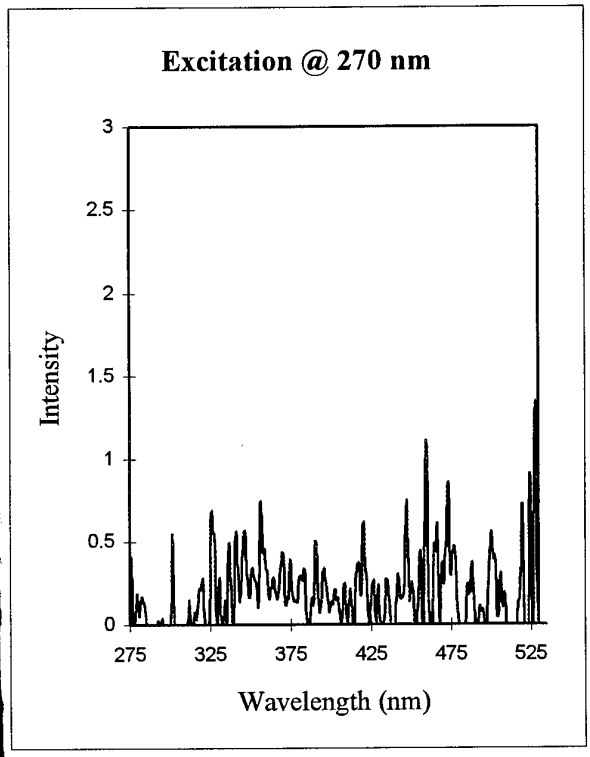

Figure 23 (d) 10/02/97 Marine

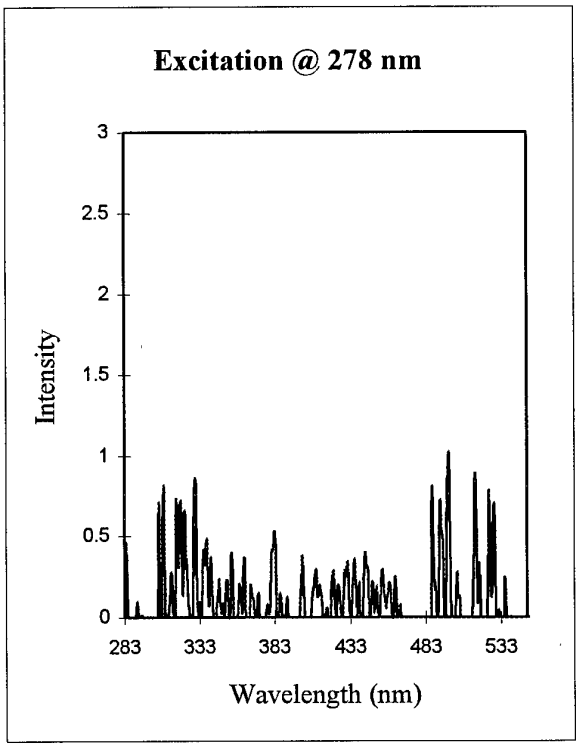

Figure 23 (e) 10/02/97 Marine

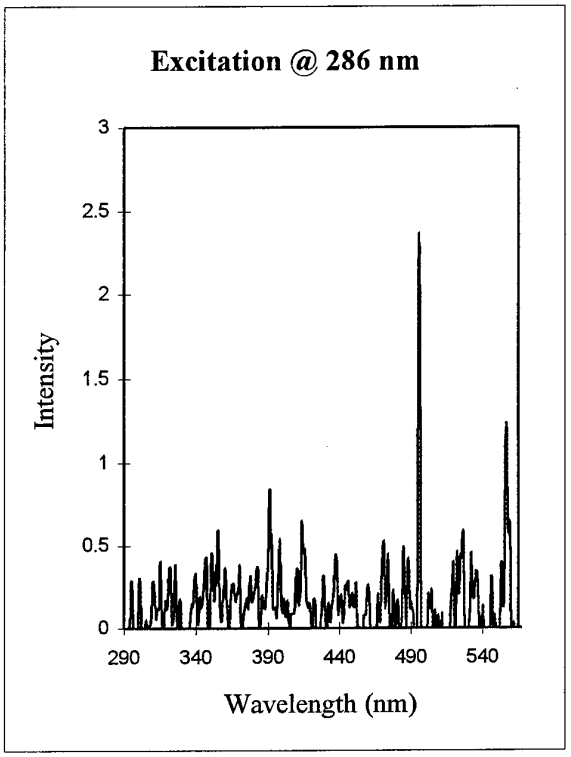

Figure 23 (f) 10/02/97 Marine

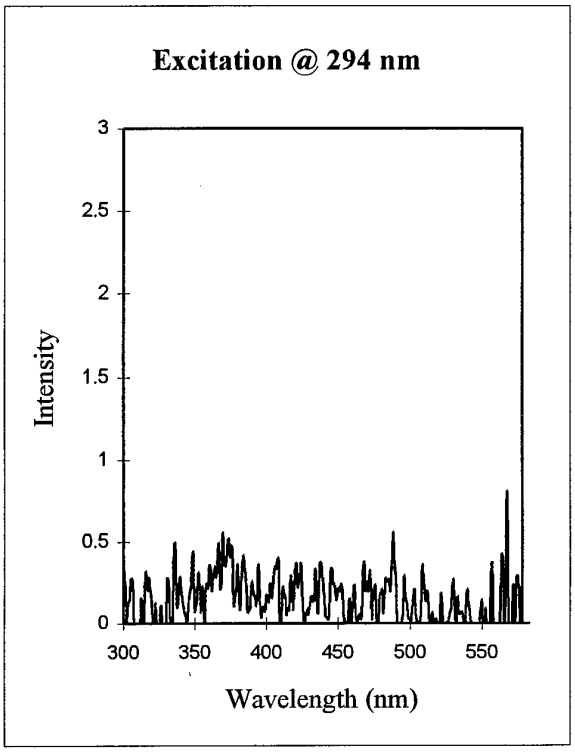

Figure 23 (g) 10/02/97 Marine

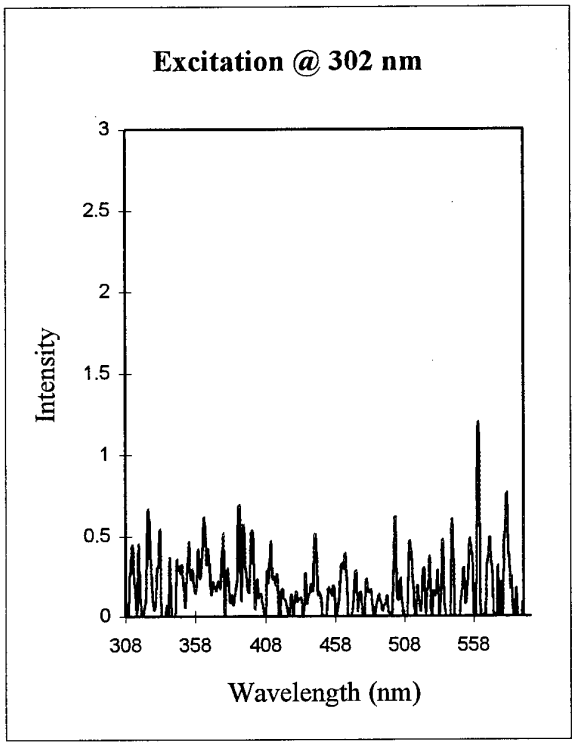

Figure 23 (h) 10/02/97 Marine

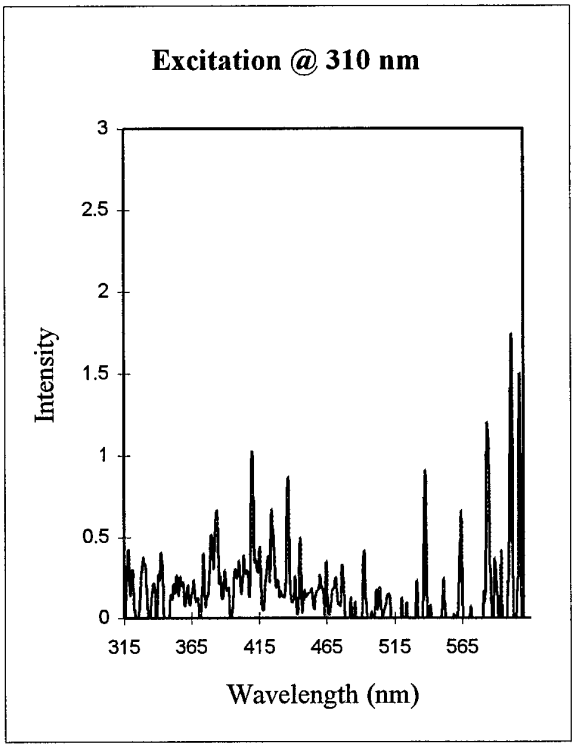

Figure 24 (a) 10/09/97 Marine

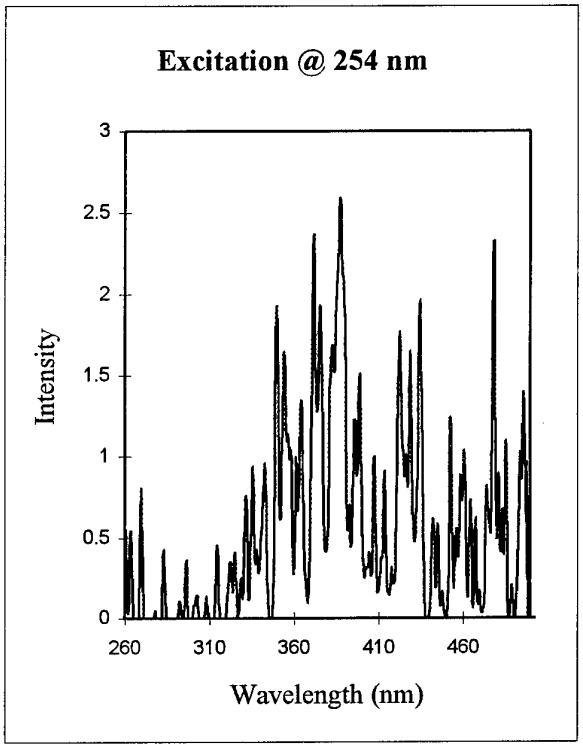

Figure 24 (b) 10/09/97 Marine

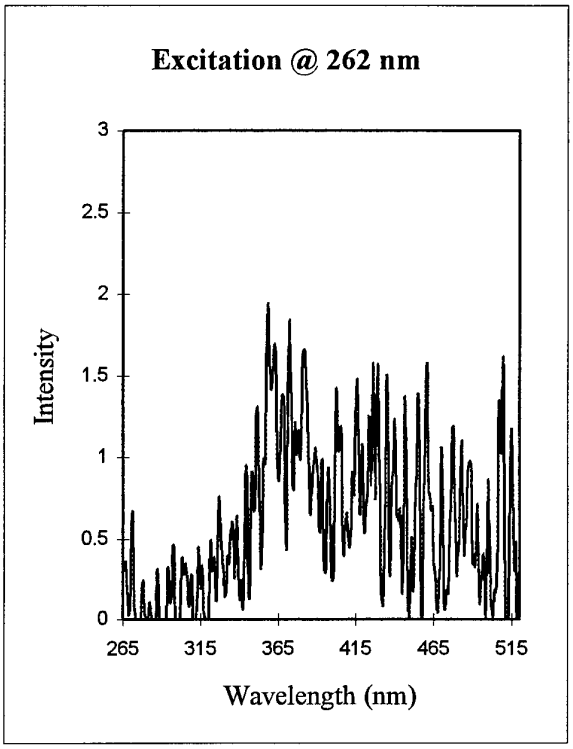

Figure 24 (c) 10/09/97 Marine

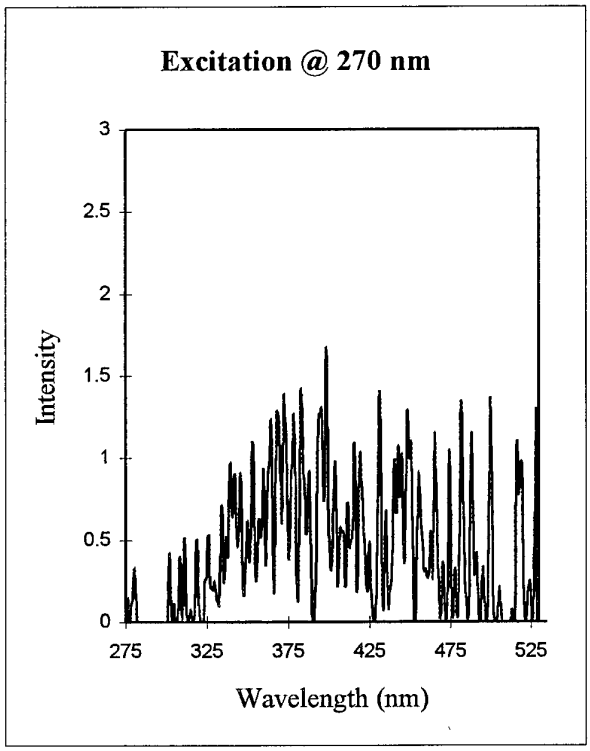

Figure 24 (d) 10/09/97 Marine

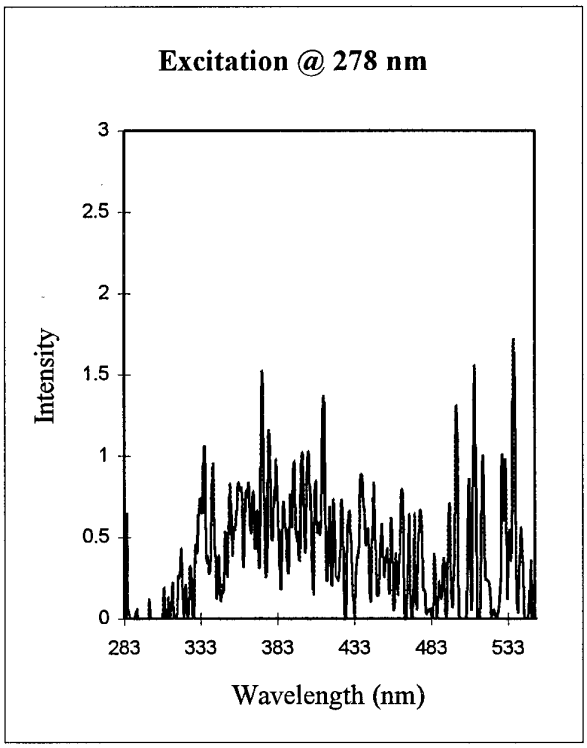

Figure 24 (e) 10/09/97 Marine

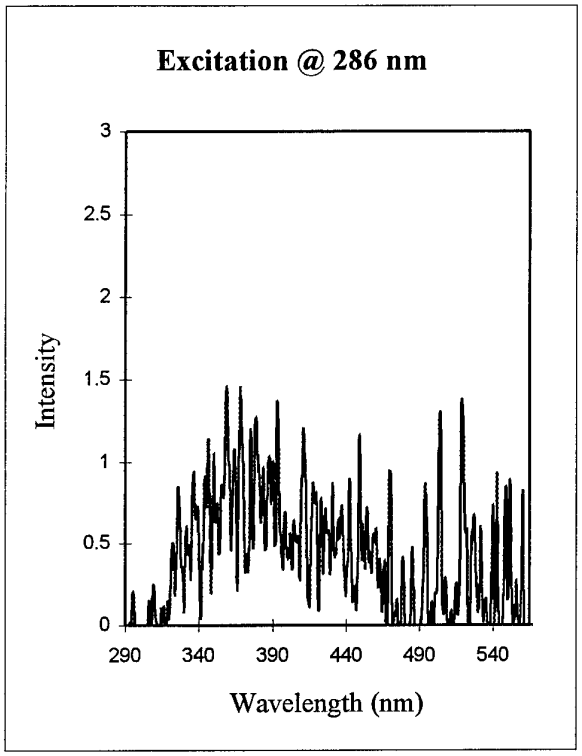

Figure 24 (f) 10/09/97 Marine

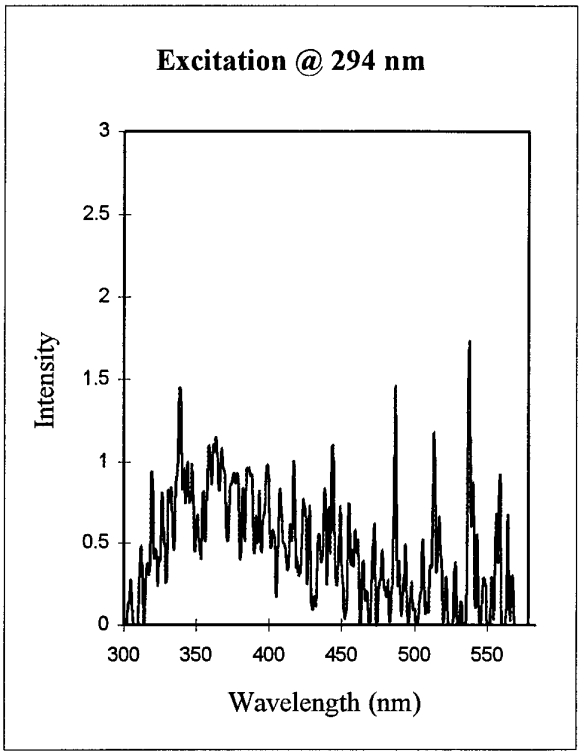

Figure 24 (g) 10/09/97 Marine

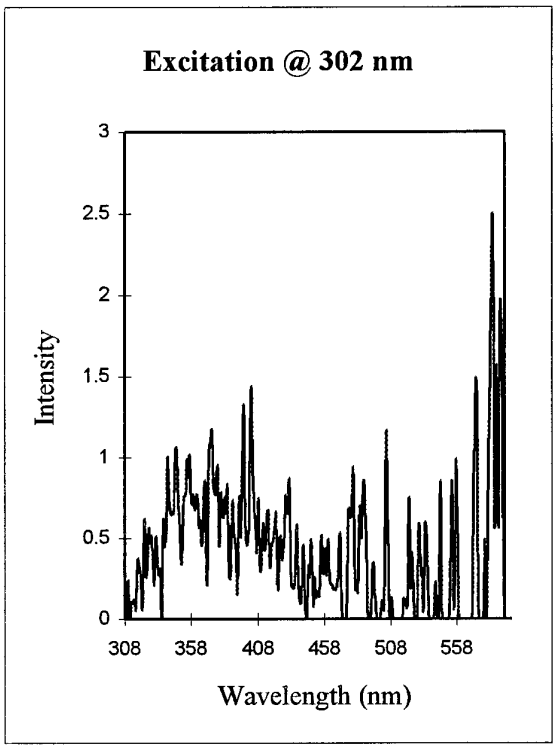

Figure 24 (h) 10/09/97 Marine

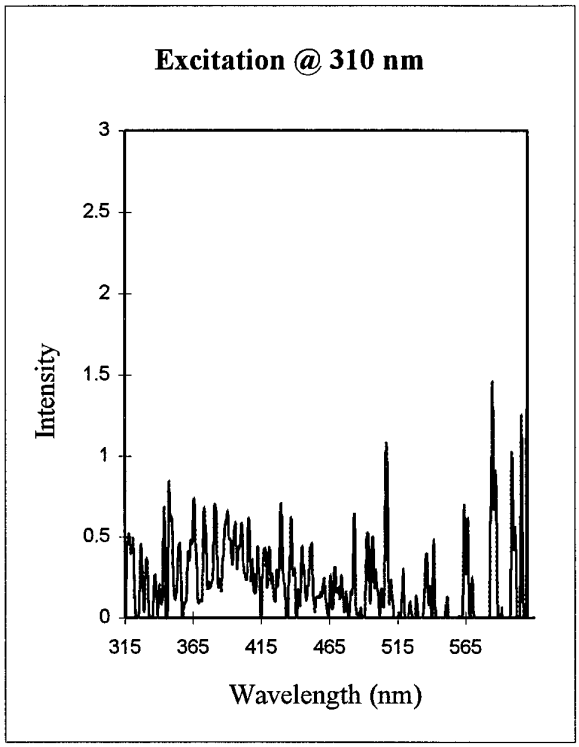

Figure 25 (a) 10/23/97 Continental

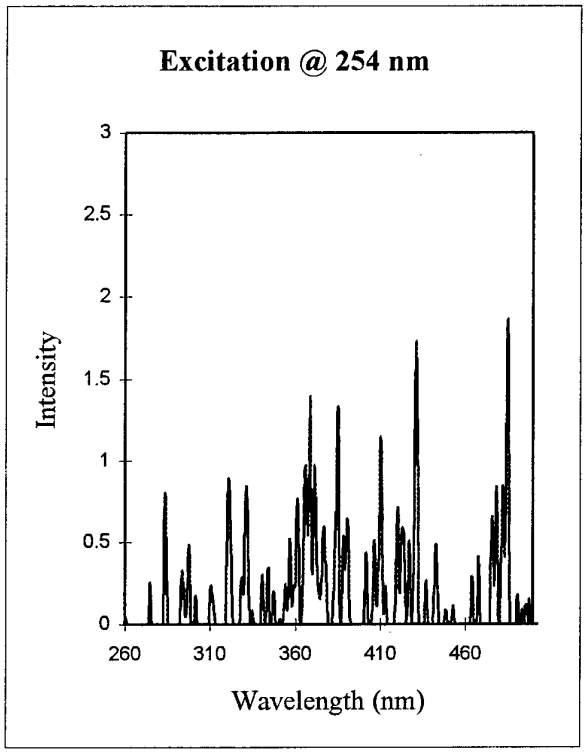

Figure 25 (b) 10/23/97 Continental

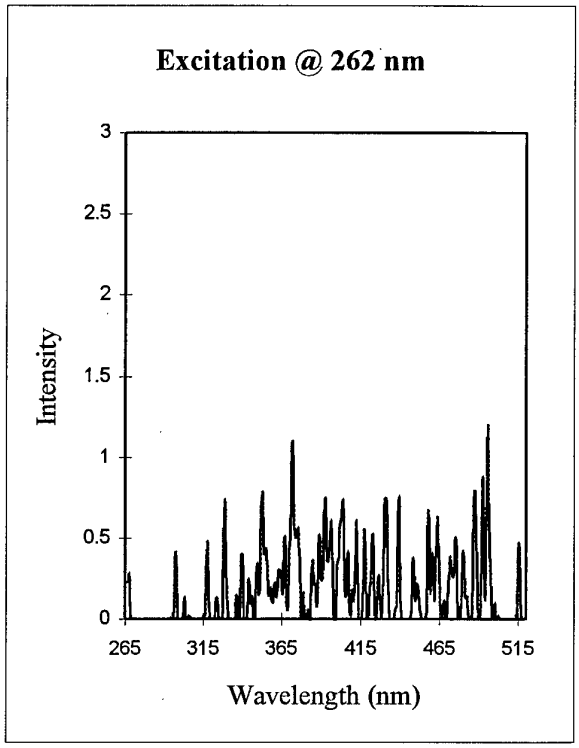

Figure 25 (c) 10/23/97 Continental

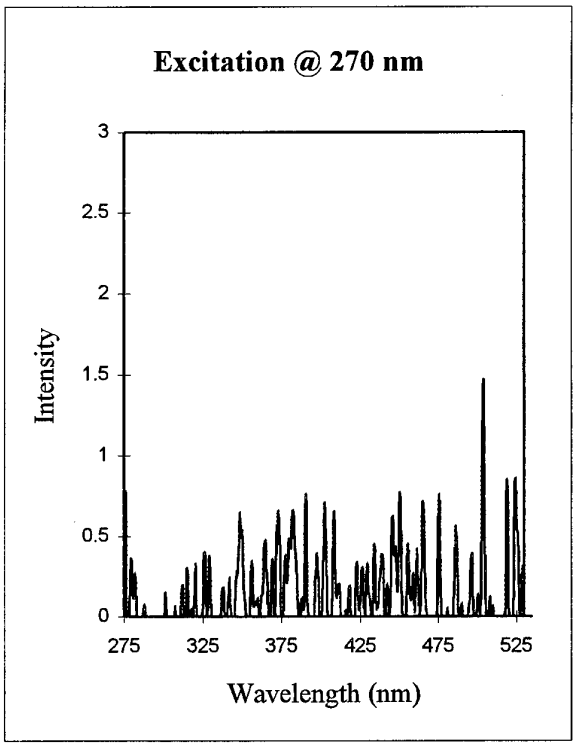

Figure 25 (d) 10/23/97 Continental

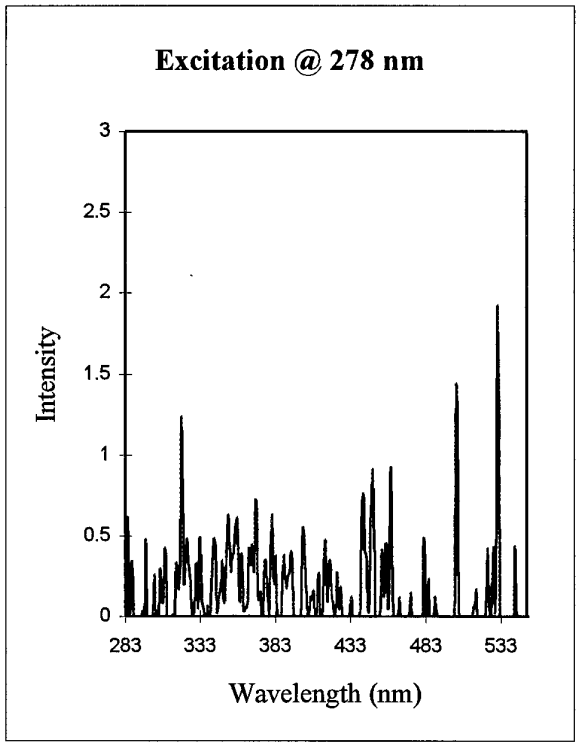

Figure 25 (e) 10/23/97 Continental

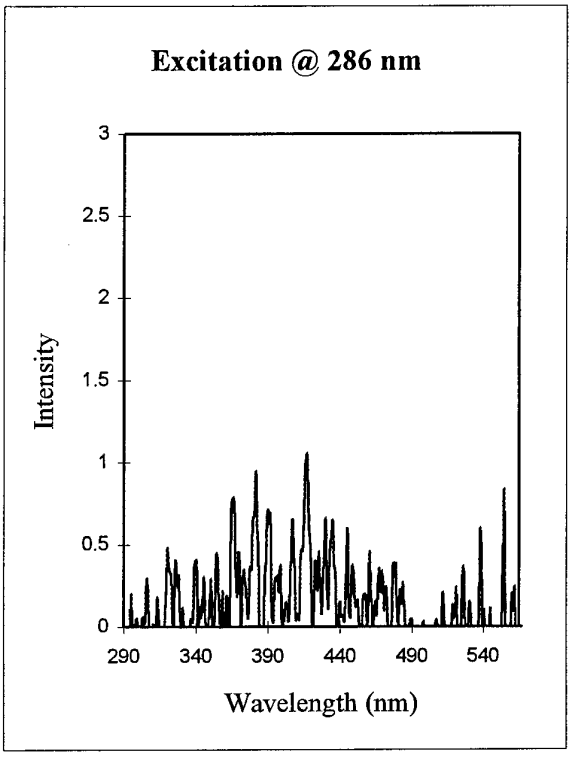

Figure 25 (f) 10/23/97 Continental

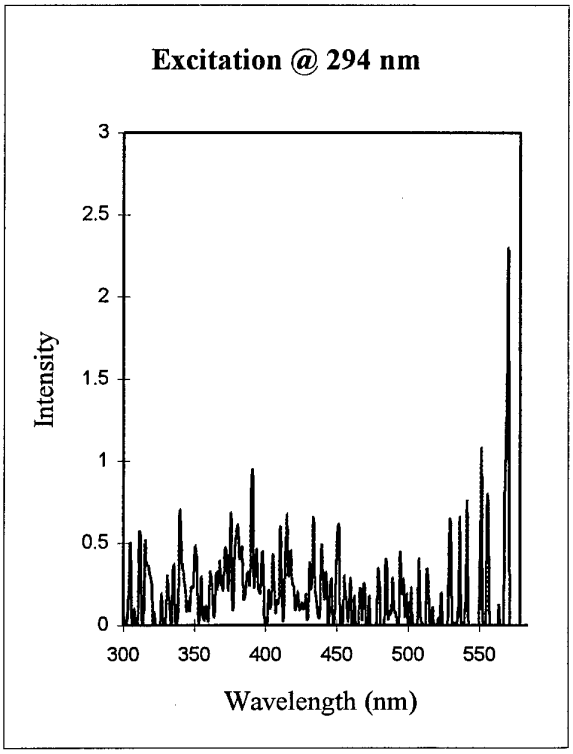

Figure 25 (g) 10/23/97 Continental

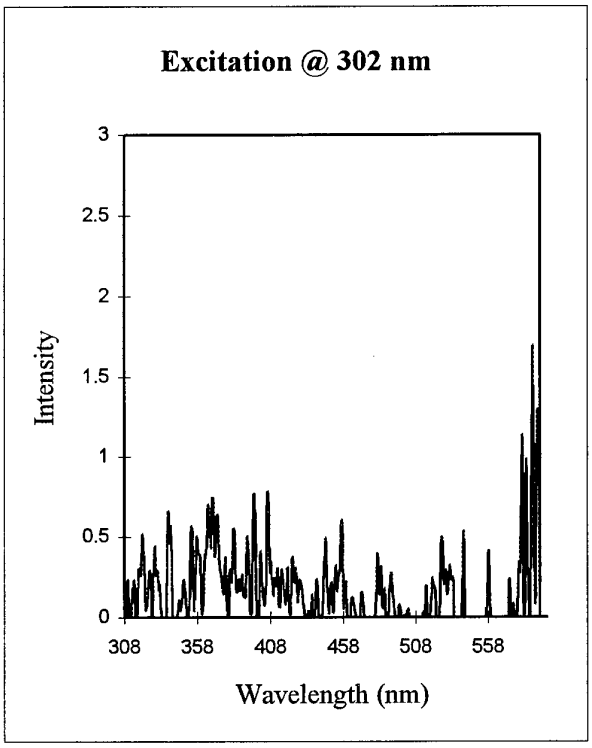

Figure 25 (h) 10/23/97 Continental